
TRAINING SERVICE
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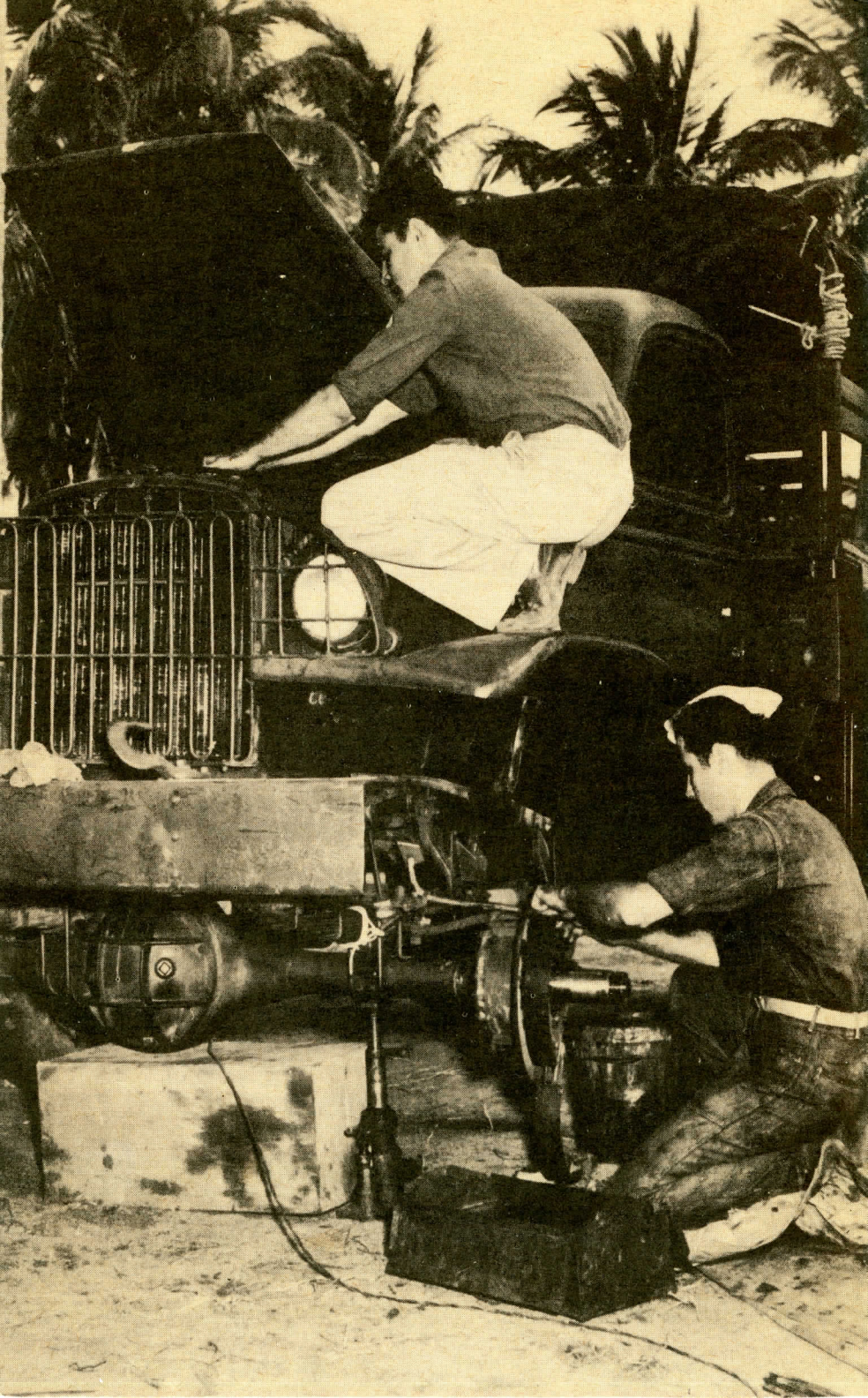
HAND TOOLS



HAND TOOLS

Their Correct Usage and Care

This booklet was prepared and issued to members of the ARMED FORCES through the courtesy of the TRAINING SERVICE SECTION GENERAL MOTORS WAR PRODUCTS

GENERAL MOTORS CORPORATION
DETROIT, MICHIGAN

FOREWORD

Our ARMED FORCES are in urgent need of more mechanics—many thousands more—to service tanks, planes, guns, armored cars and jeeps.

This fighting equipment, coming from our factories in ever increasing quantities, is being delivered to our fighting fronts and to training centers. The equipment must be serviced—kept in top notch operating condition. This will require thousands of additional well-trained mechanics.

The number of mechanics available isn't nearly enough. Thousands of men coming from civilian life must be trained. The great majority will have had little mechanical experience—some will be totally unfamiliar with tools. This booklet has been printed to help those men.

The subject is presented in a somewhat different manner than would be done in the conventional text book. Cartoons and drawings illustrate the story. Some cartoons show how tools should not be used. This booklet is meant to give the inexperienced a much better understanding of tools and their use.

The Sergeant who talks from these pages is typical of those hundreds of instructors assigned to the important task of teaching mechanics. With real sincerity of purpose and hard work these instructors are accomplishing wonders. It is to them that this booklet is dedicated—with the hope that it may make their task a little easier.

INTRODUCTION

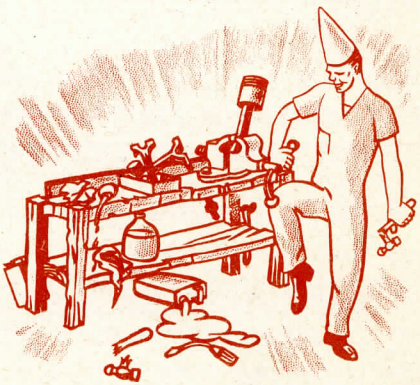
The scene: A classroom in an Army Ordnance School. The instructor, a sergeant, has just finished laying out a large assortment of tools on a long table. Before him are seated twenty-six privates.

"Good morning, men. My name is Merker, and this morning I am going to talk about tools.

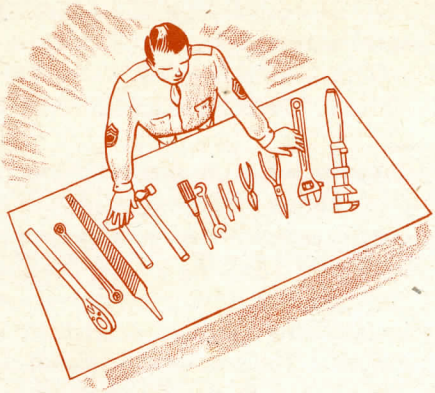
You have been assigned to this school for instruction as mechanics. This is a mechanical war. In fact, in the last war it only took 3500 HORSEPOWER to keep an infantry division in action. Today, a modern, mechanized division makes use of over 400,000 HORSEPOWER — over 110 times the horsepower used twenty-six years ago. That's the reason we need more mechanics to keep the tanks and trucks rolling. In fact, six out of every ten men who come into the Army today have to be trained specialists.

Since you are going to be mechanics, I want you to be GOOD mechanics. That means you will have to learn to use your head, your hands and your tools. It's my job to tell you something about tools and the way to use them. Some of you have probably used tools before, but I expect the majority of you are pretty green. I was that way myself some years ago when I joined up, but was lucky enough to work with a sergeant—Holland was his name—who knew his stuff. Tools were his hobby. Perhaps the idea is catching because I didn't work with that sergeant very long before it began to get into my blood too.

Before I joined up, you know, I used to operate a little repair shop and garage out in Ohio. Holland said, judging from the way I handled tools to start with, he hated to think what that shop of mine looked like. But he had a lot of patience and it wasn't long until he had taught me really how



INTRODUCTION



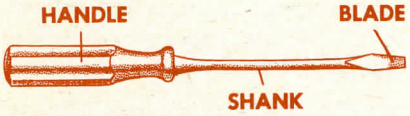
to use tools and some of the "tricks of the trade".

You know, a good mechanic always takes good care of his tools —you can look at a man's tools and tell right off the bat what sort of mechanic he is.

Here on the table is a group of hand tools. I have picked out the ones that are most used by ARMY mechanics. I shall take these up one at a time, tell what they are for, how to use them and how to take care of them. If you keep your eyes and ears open now, it's going to save you a lot of time and trouble when you get out in the shop.

SCREWDRIVERS

FIRST, we will discuss screwdrivers. Practically everyone is familiar with the standard screwdriver. The portion you grip is called the handle, the steel portion extending from the handle is the SHANK, and the end which fits into the slot in the screw is called the BLADE.



A screwdriver is intended for one principal purpose—to loosen or tighten screws. But the automotive mechanic, especially the beginner, uses it for so many other purposes that it is one of the most misused tools in his kit.

The conventional screwdriver with a slim steel shank and wood or plastic handle is designed to withstand considerable twisting force in proportion to its size. But it was not designed to be used as a pry or pinch bar and if much force is applied when it is so used, it will bend.

NEVER DO THIS

KEEP SCREWDRIVER SHANK VERTICAL TO SCREW HEAD

Another thing which may happen if the screwdriver is used for prying is that the blade may break. The tip of the blade is hardened to keep it from wearing, and the harder it is the easier it will break if much of a bending strain is applied.

There are times when a screwdriver may be used to advantage for prying, but if you use it to pry make sure that it is large enough to stand the force that is being applied. The way to avoid possible damage to your screwdrivers, of course, is not to use them for prying. Pinch bars, sometimes called pry bars, should be used instead. They are made purposely for prying and are strong enough to resist bending.

If you must use a screwdriver as a pry, use it with good mechanical judgment.

A broken blade means that a screwdriver becomes useless. It has to be reworked and retempered and that is something which requires much skill.

If the shank of the screwdriver is once bent, it usually is difficult to get it perfectly straight again. And if the shank is not straight, it is hard to keep the blade centered in the slot of the screw.

NEVER HAMMER ON THE END OF A SCREWDRIVER

Don't hammer on the end of a screwdriver—it's not to be used in place of a cold chisel, a punch or a drift. But here's another contradiction: Suppose you had to remove a rusty screw and the slot was full of rust. In such a case, it would be all right to tap gently on the handle of the screwdriver, holding it at an angle to clean the slot. And after the slot was cleared sufficiently you might want to tap on the screwdriver with a hammer to seat it well into the slot before trying to loosen the screw. But remember, be cautious and careful. Before you do any tapping on the handle, see that you have a screwdriver which has the steel shank extending through the handle. Screwdrivers which do not have the shank extending through the handle have the handle pinned to the shank, usually through the ferrule which is the metal sleeve on the handle where the shank enters. If you attempted to hammer on a screwdriver of this type, chances are the handle would split and the screwdriver would be ruined. Most of the better screwdrivers for automotive work are made with the shank going all the way through the handle so you can tap on them if the occasion requires. Some of the newer types of screwdrivers with moulded plastic handles are made to withstand tapping but others aren't, so don't take any chances. Tools cost money and right now, with the steel shortage, they are hard to get, so when you use tools, treat them gently.

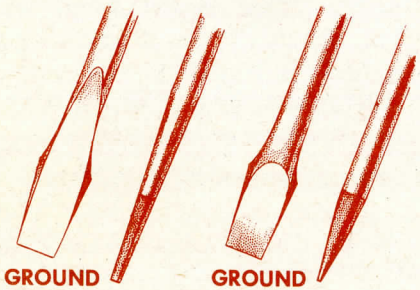
Screwdrivers for general pur-

ALWAYS SELECT RIGHT SIZE SCREWDRIVER

pose are classified by size, according to the combined length of the shank and blade, which is commonly called the BLADE. In size, they run 2½, 3, 4, 5, 6, 8, 10 and 12 inches, and the diameter or thickness of the shank and width and thickness of the blade tip which fits the screw slot are proportionate to the length of the shank. There are special purpose screwdrivers, however, which have extra thick or thin blades.

Too much emphasis cannot be placed on selecting the size of a screwdriver so that the thickness of the blade makes a good fit in the screw slot. This not only prevents the screw slot from becoming burred and the blade tip from being damaged, but reduces the force required to keep the screwdriver in the slot.

The tip of a correctly ground screwdriver blade should have the sides of the blade practically parallel. It costs more money to grind the blade like this and most manufacturers grind the blade sides so they gradually taper out to the shank body. Here is a little trick —dress the screwdriver blade on an emery wheel so the faces taper in very slightly for a short distance back of the tip. A screwdriver blade ground in this manner will stay down in the screw slot even when a severe twisting force is being exerted. A blade which tapers out from the tip, especially if the taper is extreme, has a tendency to raise out of the slot whenever much twisting is applied.



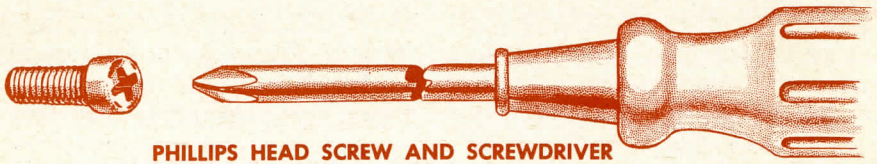
GROUND RIGHT

GROUND WRONG

NEVER USE PLIERS ON SCREWDRIVER

Here is a heavy-duty screwdriver with a square shank. It's designed that way so you can use a wrench on it. The shank is extra large—made strong enough to TAKE IT—and it's the only type of screwdriver on which you should use a wrench. DON'T USE PLIERS ON A SCREWDRIVER.

In addition to the set of general purpose screwdrivers, there are other types designed for electrical and instrument work. Some of



PHILLIPS HEAD SCREW AND SCREWDRIVER

you are familiar with the small screwdrivers with a clip for fastening them to your pocket. A mechanic's kit isn't complete without a couple of these small size screwdrivers.

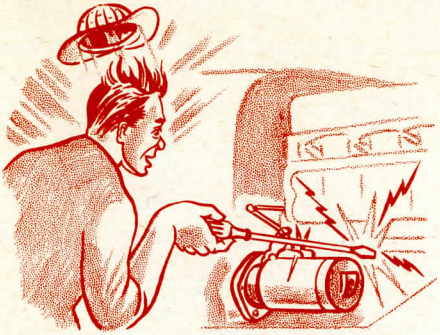
PHILLIPS TYPE SCREWDRIVERS have become very popular in recent years because of the many Phillips head screws used by automobile and truck manufacturers, especially on mouldings and other trim. The heads of these screws have two slots which cross at the center. Their advantage over screws with standard slots is that the screwdriver can't slide sideways out of the slot and mar the finish. However, more downward pressure must be exerted on the Phillips screwdriver to keep it in the cross slot than to keep a correctly ground standard screwdriver in a standard screw slot. Three sizes of Phillips type screwdrivers, a 4, 6 and 8-inch, will handle all Phillips head screws used on automotive vehicles.

Now and then an automotive mechanic has need for an OFFSET SCREWDRIVER when there isn't sufficient space to work a standard screwdriver. The offset screwdriver has one blade forged in line with the shank or handle and the other blade at right angles to the shank. With such an arrangement, when the swinging space for the screwdriver is limited, the mechanic can change ends after each swing and thus work the screw in or out of the threaded hole.

One medium and one extra large offset screwdriver should be in every automotive tool kit. The extra large size is used on drag link and tie rod ends in automobile and truck steering mechanism.

A word of caution—never use a screwdriver to check an electrical circuit where the amperage is high. By that, I mean where the electrical current is strong enough to arc and melt the screwdriver blade. This doesn't mean that you shouldn't use a screwdriver to find which spark plug is causing an engine to miss. Current to the

OFFSET SCREWDRIVER

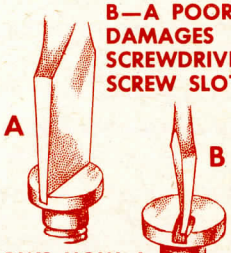


NEVER USE A SCREWDRIVER TO CHECK HIGH AMPERAGE

spark plugs is high in voltage but low in amperage and won't damage a screwdriver.

This hasn't anything to do with the use of tools but I want to caution you about wearing rings when working around batteries or starting motors. A chap in our outfit had his finger badly burned by having his ring come in contact with a starter terminal and the starter housing. The Sergeant cut the ring off before we took the fellow to the infirmary. The burn was so painful that the soldier all but passed out before we got him there.

If a screwdriver blade becomes damaged through misuse or if a corner chips off because the blade is too hard, the screwdriver can be made serviceable again by grinding it on an emery wheel. When grinding a damaged blade, first grind the tip straight and at a right angle to the shank. Never hold the screwdriver against the emery wheel very long at a time and keep dipping the blade in water to keep it cool. Unless this is done, the heat caused by friction against the emery wheel will draw the temper and the blade will become soft. After the tip is ground square dress off a little at a time from each face. Be careful to keep the blade thick enough to make a fairly tight fit in the slot of the screw for which the screwdriver is intended. Keep the faces parallel for a short distance or have them taper in a slight amount. Never grind the faces so they taper to a sharp edge at the tip.



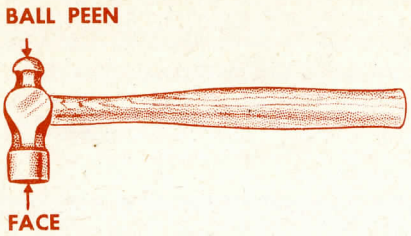
B—A POOR FIT DAMAGES SCREWDRIVER AND SCREW SLOT

A—SHOWS HOW A SCREWDRIVER SHOULD FIT THE SCREW SLOT

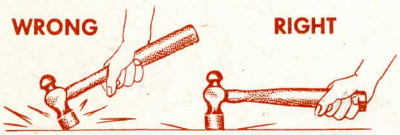
HAMMERS

THERE are many types of hammers. The ball peen hammer is the one used most by automotive mechanics. The flat portion of the head, used for most hammering, is called the FACE and the other end the PEEN. When the peen is ball-shaped, it is known as a BALL PEEN. The ball peen is used principally for riveting. The hole for the handle is the EYE.

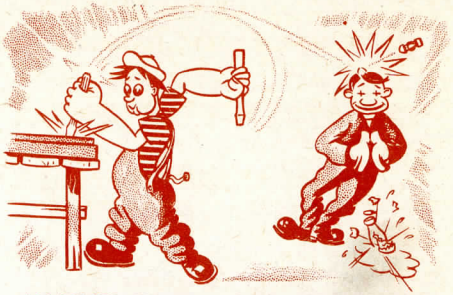
MACHINIST HAMMERS



Ball peen hammers are classed according to the weight of the head without the handle. Usually they weigh 4, 6, and 8 and 12 ounces, and 1, 1½ and 2 pounds. A good combination to have is a 12-ounce, a 1½ pound and a 4 or 6 ounce. A little hammer comes in very handy for light work, and especially when cutting gaskets out of sheet stock. The small ball peen does a good job of cutting out the holes for cap-screws or studs.



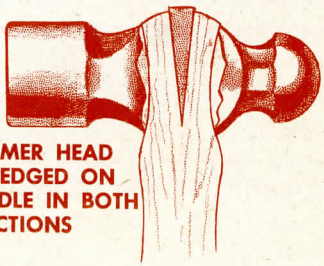
Simple as the hammer is, there are right and wrong ways to use it. The beginner usually has a tendency to grip the handle too close to the head. This is known as CHOKING a hammer. It reduces the force of the blow and makes it harder to hold the hammer head in an upright position. When you want to strike a heavy blow, grip the handle close to the end. This increases the length of the lever arm and makes the blow more effective. Whenever possible, strike the object with the full face of the hammer. Try to hold the



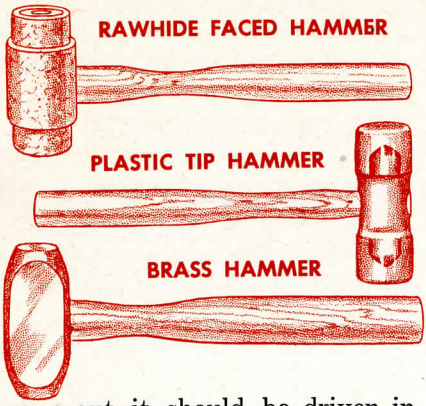
HAMMER HANDLE SHOULD ALWAYS FIT HEAD TIGHTLY

hammer at such an angle that when it strikes the object the face of the hammer and surface of the piece being hit will be parallel. This distributes the force of the blow over the entire hammer face and avoids damaging its edge.

The hammer handle always should be tight in the head. Never work with a hammer having a loose head. This is dangerous because the head may fly off and cause an injury. The eye or hole in the hammer head is made with a slight taper in both directions from the center. After the handle, which is tapered to fit the eye, is inserted in the head a steel wedge is driven into the end of the handle. This expands it in the opposite taper in the eye and thus the handle is wedged in both directions. If the wedge starts to



HAMMER HEAD IS WEDGED ON HANDLE IN BOTH DIRECTIONS



come out it should be driven in again to tighten the handle. If the wedge comes out and is lost, replace it before continuing to use the hammer. If you can't get another wedge right away, you can file one out of a piece of flat steel or cut one from a portion of the tang of a worn-out file. The tang is the end of the file which fits into the handle.

Never use an ordinary hammer where there is danger of damaging either the surface being struck or the face of the hammer. When you have to use a hammer on a machined surface protect that surface with a piece of soft brass, copper, lead or a hardwood block.

For certain classes of work, special hammers with rawhide, plastic or lead faces are used to prevent damaging the work. The plastic hammer is fast becoming a favorite with mechanics.

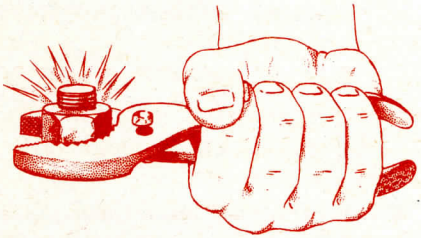
Don't use the end of the hammer handle for bumping purposes, such as tapping ball bearings into place, as this will split and ruin the handle. And never use the handle for prying. Handles are easily broken that way. Keep your hammers clean—every now and then give them a bath in fuel oil or some other cleaning solvent.

PLIERS

PLIERS are the next tools on our list. There are many types. The pliers most commonly used in automotive work are the 6-inch combination slip-joint pliers usually called COMBINATION PLIERS. The slip joint permits the jaws to be opened wider at the hinge pin for gripping large diameters. Combination pliers come in the following sizes: 5, 6, 8 and 10 inches. This is a measure of their overall length. In addition to

the 6-inch size, you'll usually find the well equipped mechanic has 5-inch pliers for light work, also 10-inch pliers for heavy work. Some combination pliers are made with a side cutter arrangement for cutting wire and cotter pins. The better grades of combination pliers are drop forged steel and withstand hard usage.

Avoid using pliers on a hardened surface as this dulls the teeth and pliers LOSE THEIR GRIP.



DON'T USE PLIERS ON NUTS

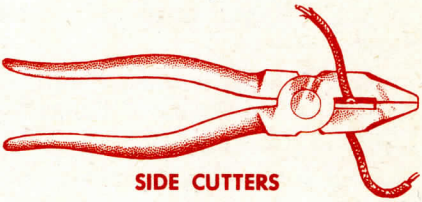
Beginners in this business sometimes use pliers for loosening or tightening nuts. A good mechanic loses his respect for any man he sees doing this. Always use wrenches on nuts—never pliers. In fact, don't use pliers when any other tool will work.

Another type of pliers which is very useful in automotive work are the diagonal cutting pliers, usually referred to as DIAGONALS. Because the cutting jaws are at an angle these pliers are ideal for pulling cotter pins, especially when the cotter pins are in castellated nuts used on connecting rod and main bearing caps. When installing cotter pins diagonals also come in very handy for cutting the cotter pin to the right length and for spreading the ends of the pin after it is put in the hole.

DIAGONAL PLIERS

DUCKBILL PLIERS

Long nose pliers, either the flat nose or duck bill type, often help a mechanic out of a tight spot such as recovering a washer or a nut which gets into a place where it's hard to reach. Long nose pliers make it easier to remove and install valve spring retainer pins used on some engines.



SIDE CUTTERS

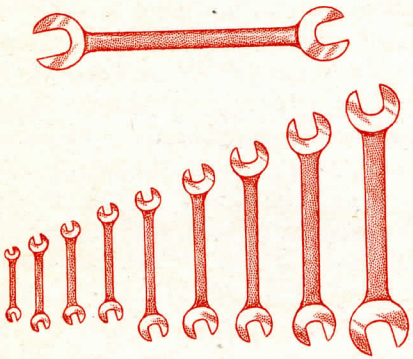
The mechanic who does considerable electrical work also will have a pair of 5 or 6-inch regular side cutting pliers for cutting primary and high tension ignition wire and making other wire replacements in the electrical system.

Pliers, like all other tools, should be kept clean. Give them an occasional bath to wash off the dirt and grit. Put a drop of oil on the joint pin. These precautions cut down wear and prevent rust-

ing, which is a vicious enemy of all tools.

OPEN-END WRENCHES

SOLID, non-adjustable wrenches with openings in each end are called open-end wrenches. The average set in a good tool kit numbers about 10 wrenches with openings that range from $\frac{5}{16}$ to 1 inch in width. This combination of sizes will fit most of the nuts, cap-screws and bolts used on automotive vehicles.

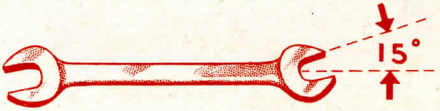


The size of the openings between the jaws determines the size of the wrench. The smallest wrench in the ordinary set has a $\frac{5}{16}$ inch opening in one end and a $\frac{3}{8}$ inch opening in the other. Consequently, it would be called a $\frac{5}{16}$ by $\frac{3}{8}$ open-end wrench. These figures refer to the distance across the flats of the nut or bolt head and not to the bolt diameter. The openings actually measure from five to fifteen thousandths of an inch larger than the nominal sizes marked on the wrenches so that they can easily be slipped onto the nuts or bolt heads.

The smaller the openings in the wrench, the shorter its overall length. This proportions the lever advantage of the wrench to the size of the bolt or stud. With a given amount of pull on a wrench, a short one will produce less twisting effort on the nut than a longer one. This helps reduce the possibility of the mechanic applying too great a force at the nut which would either strip the threads or twist the stud or bolt in two. Wrenches with larger openings are made proportionately longer to increase the lever advantage. And they are made heavier to provide the required strength.

In addition to a standard set of wrenches, the good mechanic will have a set of 3 or 4 very small wrenches for ignition and carburetor work and for machine screw nuts used on electrical equipment. I have a set of these wrenches in a little tool roll and frequently they come in mighty handy.

Open-end wrenches have the head and opening at an angle to the body—most of them are 15 degrees, others 22½ degrees. One day I asked my Sergeant why they were made that way. He told me



that the next time I was working with a wrench in CLOSE QUARTERS to figure that one out for myself. Later that afternoon I had the answer. I was loosening a nut and there was very little space in which to swing the wrench. I found that by FLOPPING the wrench—turning it over so that the other face was down after each stroke—the angle of the head was reversed and would always fit the next two flats on the hexagon nut so I could keep turning it off. The 15 degree angle and the FLOPPING trick enable you to turn a hexagonal or six-sided nut continuously when the swing of the wrench is limited to 30 degrees, which is only one-half the swing which would be required if the wrench opening were straight and not at an angle with the body of the wrench.

Special types of open-end wrenches have the angle of the opening at 75 degrees and others at 90 degrees.

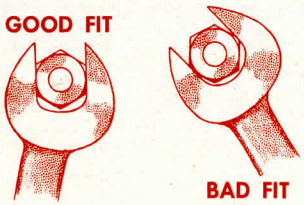
There are special open-end wrenches, such as tappet wrenches, which are thin and have extra long handles that enable a mechanic to adjust valves on a hot engine without burning his hands.

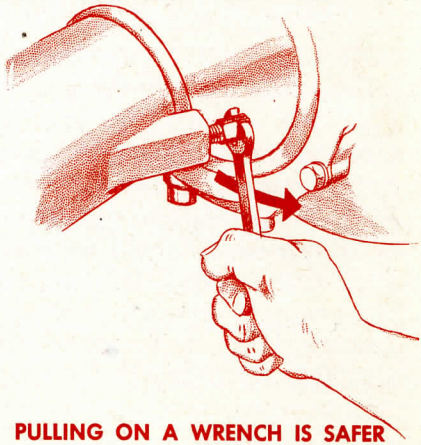
There are a few simple rules

DANGEROUS TO PUSH ON WRENCH

for the correct use of open-end wrenches: Be sure that the wrench fits the nut or bolt head.

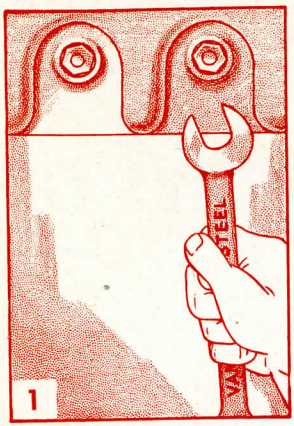
When you have to put a hard pull on a wrench, such as when loosening a tight nut or tightening a loose nut, make sure the wrench seats squarely on the sides of the nut. Always PULL on a wrench—don't PUSH. Pushing on a wrench is dangerous. When you push on a wrench to loosen a tight nut and the nut BREAKS LOOSE unexpectedly, you will invariably strike your knuckles against some part you overlooked and knock off some HIDE. This is not a hard and fast rule—there are

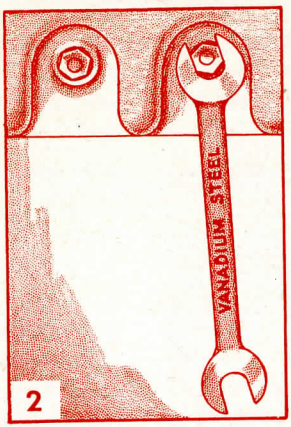


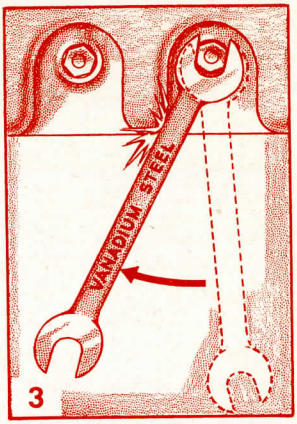


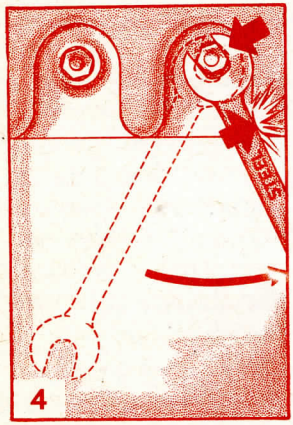
PULLING ON A WRENCH IS SAFER

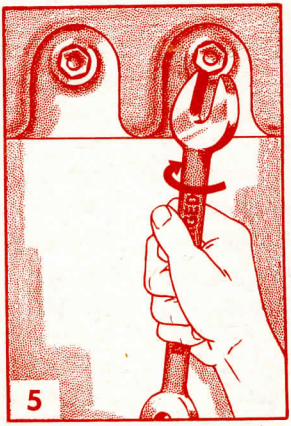
WRENCHES

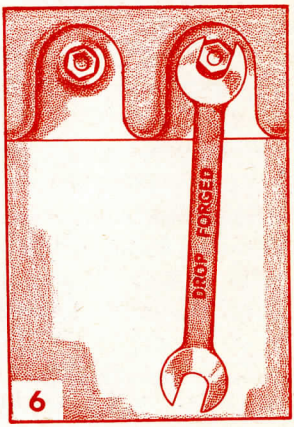


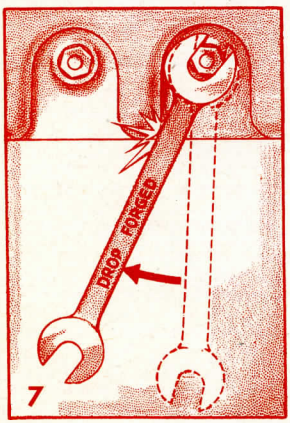












This series of illustrations shows how a wrench, with head at a 15 degree angle to the body, can be used to turn a nut when *"swing space"* is limited to 30 degrees.

1. Wrench, with opening sloping to the left, about to be placed on nut.
2. Wrench positioned and ready to tighten nut. Note that space for swinging the wrench is limited.
3. Wrench has been moved clockwise to tighten the nut and now strikes the casting which prevents further movement.
4. Wrench is removed from nut and turned counter clockwise to be placed on the next set of flats on nut. But corner of casting prevents wrench from fitting onto the nut.
5. Wrench is being flopped over so that wrench opening will slope to the right.
6. In this flopped position, the wrench will fit the flats on the nut.
7. Wrench now is pulled clockwise to further tighten nut until wrench again strikes casting. By repeating the flopping procedure, the nut can be turned until it is tight.

exceptions. Sometimes this is the only way you can work the wrench. So if you must push on the wrench, use the base of the palm and hold your hand open. This will save your knuckles.

I haven't much sympathy for any man who bangs his knuckles or cuts himself—it is just plain carelessness and usually there isn't any excuse for it.

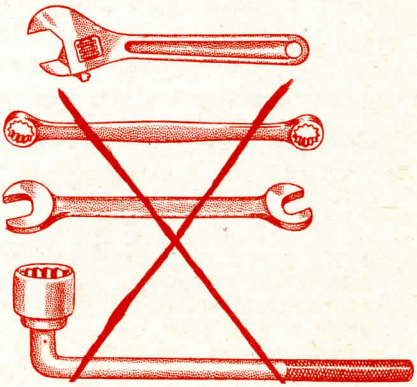
It will take practice for some of you men to know whether you are using enough or too much force on your wrenches. Experience develops a sense of "feel" which enables a mechanic to know whether a nut or cap-screw is tightened the right amount.

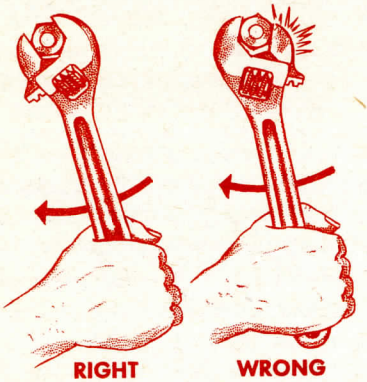
ADJUSTABLE WRENCHES

ADJUSTABLE WRENCHES are shaped somewhat similar to open-end wrenches but have one jaw adjustable. I don't know how they ever got their name because the ordinary monkey wrench is also adjustable. I have been told that the monkey wrench got its name from the inventor, Charles Monnkey—spelled with two n's. However, whenever the term "adjustable wrench" is mentioned it refers only to a wrench which is somewhat like an open-end wrench but has an adjustable jaw. The angle of the opening to the handle on an adjustable wrench is 22½ degrees. The usual set of adjustable wrenches consists of a 4, 6, 8, 10 and 12 inch wrench, but they also are made in 15 and 18 inch. A large 18-inch adjustable wrench is very useful for maintenance work on tanks. Some wrench manufacturers make double-end adjustable wrenches with an adjustable opening on each end.

Although adjustable wrenches are especially convenient at times, they are not intended to take the place of standard open-end wrenches, box wrenches or socket wrenches. Smaller adjustable wrenches are principally used when you find an odd size nut or bolt that one of your open-end wrenches or socket wrenches doesn't fit.

The mechanic who is going to handle emergency service will find





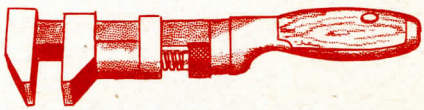
that a 6, 8 and 12-inch adjustable wrench will be very handy to have in his kit. They cut down on the number of open-end wrenches he will have to carry.

Adjustable wrenches aren't intended for hard service—treat them gently. Whenever you have to exert any amount of force on an adjustable wrench to "break loose" a tight nut or "snug down" a nut which is being tightened—there are two important points to remember. First, always place the wrench on the nut so that the pulling force is applied to the stationary jaw side of the handle. Adjustable wrenches can withstand the greatest force when used in this manner. Second, after placing the wrench on the nut, tighten the adjusting knurl so the wrench fits the nut snugly. If these two precautions are not observed the life of an adjustable wrench will be short.

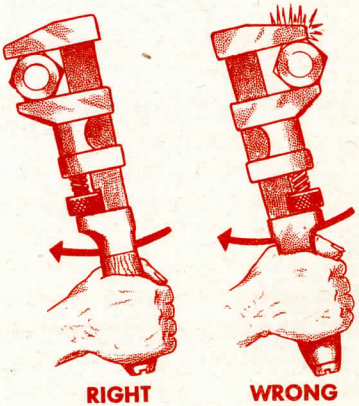
Adjustable wrenches, like all other tools, should be kept clean. Give them an occasional bath in fuel oil or a cleaning solvent and apply a little light oil to the knurl and the sides of the adjustable jaw where it slides in the body. Inspect them for cracked knurls or jaws which may result in failures.

MONKEY WRENCHES

THE monkey wrench is familiar to most of us. Its use in automotive work has been replaced almost entirely by the large adjustable



wrenches and special purpose box wrenches. In the smaller sizes as supplied in automobile tool kits the all steel monkey wrench is known as an auto wrench.



The same precautions for the use of adjustable wrenches apply to monkey wrenches. If the pull is not exerted on the right side of the handle—opposite the opening—it is easy for the wrench to slip and it might be ruined.

I remember one of my Sergeant's many expressions on the use of tools was "only a monkey would hammer on a monkey wrench." That's something that shouldn't be done on any wrench except a few types purposely made for such use. Hammering on a wrench or slipping a pipe over the handle in order to increase leverage puts a strain on the wrench which it isn't designed to take. If the strain is excessive, something has to bend or break.

PIPE WRENCHES

THERE is need on rare occasions in the automotive shop for using a pipe wrench, but only on round objects—never on hexagon or square nuts. The teeth on the

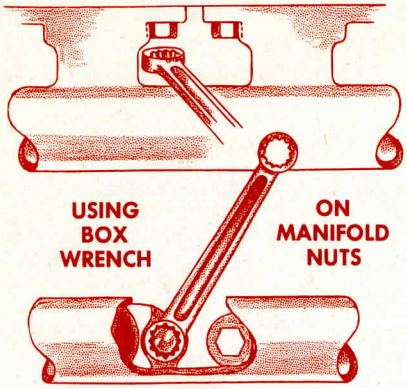
jaws of the pipe wrench always leave their mark on the work. No instructions are necessary on which way to pull on this wrench because it works only in one direction. However, the wrench works best when the "bite" is taken at about the center of the jaws.

Pipe wrenches are made in sizes ranging from 6 to 48 inches. The 6-inch wrench takes pipe from $\frac{1}{8}$ to $\frac{1}{2}$ inch. Pipe size refers to the inside diameter. The 48-inch pipe wrench will handle 1-inch up to 5-inch pipe. A few drops of oil applied to the adjusting nut makes it easier to work.

BOX WRENCHES

BOX wrenches are very popular among mechanics. One reason for this is that they can be operated in very close quarters. They are

called "box" wrenches because they box or completely surround the nut or bolt head. In place of a hexagon or six-sided opening, there



are 12 notches arranged in a circle. A wrench with this type opening is called a 12-point wrench. A 12-point wrench can be used to continuously loosen or tighten a nut with a minimum swing of the handle of only 15 degrees compared to a 60-degree swing of the standard open-end wrench, or to a 30-degree swing with the open-end wrench if it is flopped after every swing. A 60-degree swing is one-sixth of a full circle. Another advantage of the box wrench is that there is no chance of the wrench slipping off the nut and it can't spread on the nut. Because the sides of the opening in a box wrench are so thin, it is ideally suited for nuts which are hard to get at with an open-end wrench.

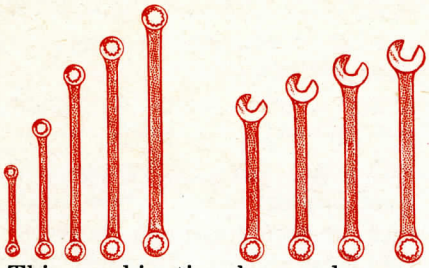
In addition to the regular box wrenches with straight handles, some have the heads set at an angle of 15 degrees to the handle. This tips the end of the wrench which is not on the nut upward and provides clearance for the mechanic's hand.

Box wrenches are also made with an offset on either one or both ends. Again, the purpose of these designs is to provide clearance for obstructions in the working space and for the mechanic's hand. Some mechanics call these offset box wrenches "knuckle savers."

There is one disadvantage to using box wrenches. While they are ideal to "break-loose" tight nuts or pull tight nuts tighter, the mechanic loses time when he uses a box wrench to turn the nut off the stud or bolt once it is broken loose. This is because the wrench has to be lifted completely off the nut, then placed back on the nut in another position. This would not be true, of course, with nuts where there is sufficient clearance to spin the wrench in a full circle.

COMBINATION BOX AND OPEN-END

After a tight nut is broken loose it can be completely backed-off or unscrewed much more quickly with an open-end wrench than with the box wrench. This is why many mechanics prefer combination wrenches—a box wrench on one end and an open-end wrench on the other. They use the box end for "breaking-loose" or "snugging down" nuts and the open-end for otherwise turning the nut.



This combination box and open-end wrench is sometimes called a "half and half."

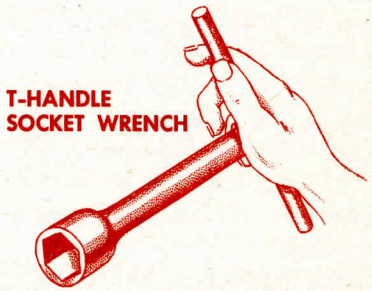
For very heavy duty work, large box wrenches are made to be used with long extension handles to provide great leverage and permit the mechanic to apply all of his muscular ability.

You never should hammer on a wrench, but there is one exception. There's a type of box wrench made for this purpose. These wrenches are heavy and strongly made. The handle is short and has a pad on which the hammer blows are struck. These box wrenches are known as "slugging" or "striking" wrenches.

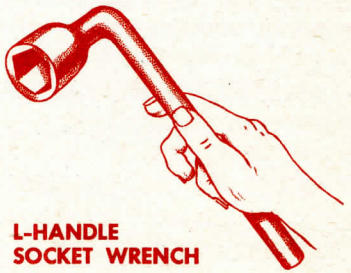
SOCKET WRENCHES

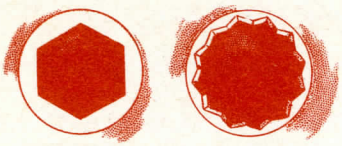
THE type of wrench which has done most to make the mechanic's work easier and save time is the socket wrench.

The modern socket wrench kit such as you see here is far different, of course, from the earlier types. More attention has been given to the development and improvement of present day socket wrench sets than to any of the other commonly used automotive hand tools.



The first socket wrenches to be used on automobiles had the socket formed as part of the handle which was either "T" or "L" shaped. Each size socket was



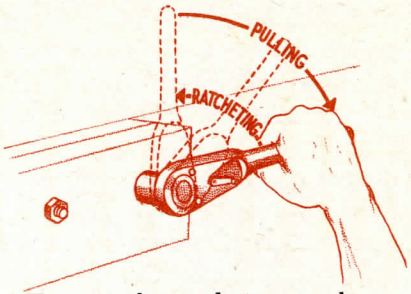


EARLY TYPE 6-POINT SOCKET

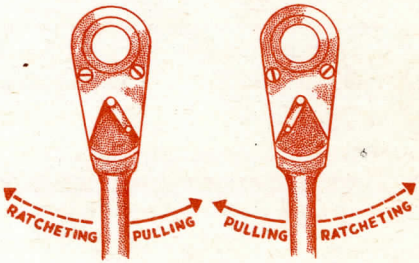
MODERN 12-POINT SOCKET

made as a separate wrench. Then someone got the idea of having one handle on which could be fitted any of the different sizes of sockets in the set. The next improvement was the ratchet type handle.

The detachable sockets have been greatly improved over the earlier types. The early sockets were large and heavy with thick walls. They had to be made that way to provide sufficient strength to stand the strain. The opening for the nut or bolt head was hexagonal—six sided. They were vastly different in appearance from the present sockets which are made out of high strength alloy steel and consequently can have thin walls and at the same time be very strong. You will notice that the openings in these sockets are formed by cutting a series of notches in a circular hole. Because there are twelve of these notches it is called a 12-point socket. The 12-point socket can be positioned on a nut more quickly than a hexagon shaped socket because it requires less than one-twelfth of a turn—usually much less—to fit it onto the nut as compared with up to one-sixth of a turn for the hexagonal socket.



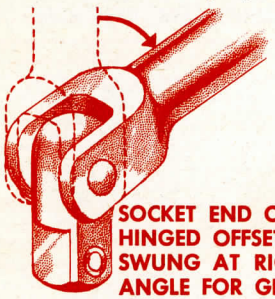
To use the socket wrench you select the size of socket that fits the nut, engage it on the ratchet handle and place the socket on the nut. Inside the head of the ratchet handle is a pawl or dog which engages or fits into one or more of the ratchet teeth. Pulling on the handle in one direction, the dog holds in the ratchet teeth and turns the socket. Moving the handle in the other direction, the dog ratchets over the teeth, permitting the handle to be backed up without moving the socket. That's why the ratchet handle can be worked so rapidly—the socket does not have to be raised off the nut to get another "bite." The handle ratchets in one direction when tightening a nut and in the other direction when loosening a nut. A means usually is provided on the handle for changing the



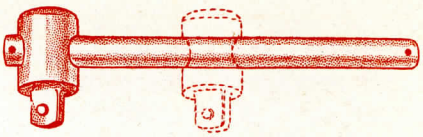
direction of ratcheting. On some makes there is a little lever which is flipped to the right to make the head ratchet when the handle is moved in a counter-clockwise direction. This is the way you want it to work when tightening a nut. When unscrewing a nut the lever is flipped to the left and the handle then ratchets in a clockwise direction.

The reason that a modern socket wrench set is so adaptable for repair work is that in addition to the set of sockets and the ratchet handle, it contains numerous other accessories. The hinged offset handle is very convenient. To loosen a tight nut the handle can be swung so as to be at a right angle to the socket and thus provide the greatest possible leverage. Then, after the nut is loosened to the point where it turns easily, the handle can be hinged into the vertical position and twisted by the fingers to completely remove the nut from the bolt or the stud.

Mentioning the term "stud" reminds me that some of you men may not know what a stud is. As a mechanical term, the word



SOCKET END OF HINGED OFFSET HANDLE SWUNG AT RIGHT ANGLE FOR GREATEST LEVERAGE



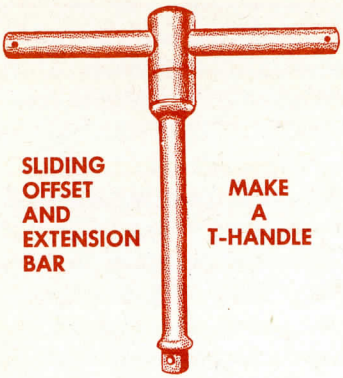
SLIDING OFFSET HANDLE

"stud" hasn't anything to do with horses. All of you are familiar with a bolt with threads on one end and a head on the other. If we were to cut off the head and put threads on both ends, it would be a stud, sometimes called a stud bolt. Studs are used in numerous places, particularly on engines. There they are screwed into the engine casting and used to attach the cylinder head, to hold the main bearing caps in position, to attach manifolds, and for many other purposes. Studs for automotive use that are screwed into castings have a coarse thread on that end and usually a fine thread on the end on which the nut goes. Coarse threads in castings are much stronger than fine threads.

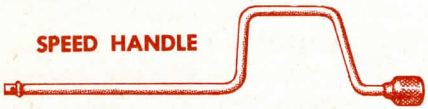
When it comes to defining the difference between bolts and capscrews, in automotive practice there isn't any and the two terms are used interchangeably without distinction.

Getting back to the other pieces in the socket wrench set—there is a sliding offset handle. The head can be positioned at the end or at the center of the handle. The sliding offset and an extension bar can be made up as a "T" handle.

Speed handles sometimes called "speeders" or "spinners" are convenient for many jobs such as

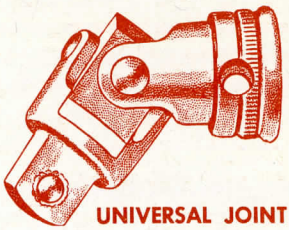


removing or tightening oil pan screws. The speed handle is worked like a brace which the woodworker uses with a bit to



bore holes. A speed wrench will help you get cylinder head nuts off in a hurry after they are first broken loose with the sliding offset or the ratchet handle.

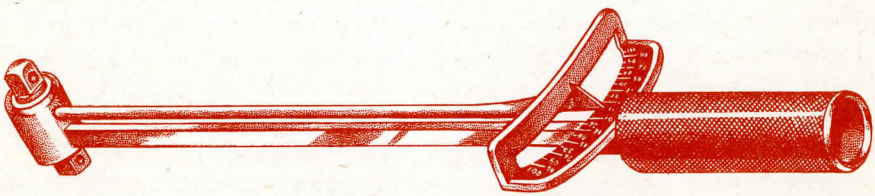
A universal joint frequently comes in very handy when working on nuts in those places where a straight wrench cannot be used. The universal joint enables you to


UNIVERSAL JOINT

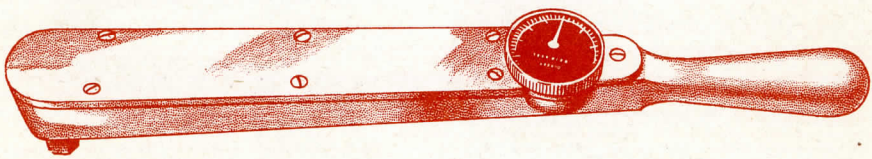
work the wrench handle at an angle with the socket. Often this is a big help when working in close places.

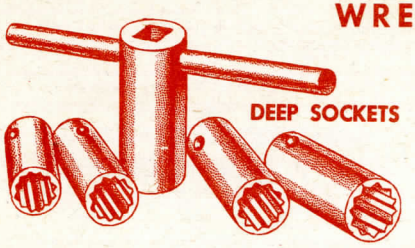
Large socket wrench sets also contain about five extra deep sockets for use on spark plugs and on nuts which are a long way down on the bolts, such as on "U" bolts that are used to attach chassis springs to the axles.

Another accessory for the socket wrench set is a handle which measures the amount of pull you put on the wrench. This is called a "torque wrench." Torque is the amount of turning or twisting force applied on the nut. On some makes of torque wrenches a pointer indicates on a scale the amount of force being applied. On



TWO TYPES OF TORQUE WRENCHES





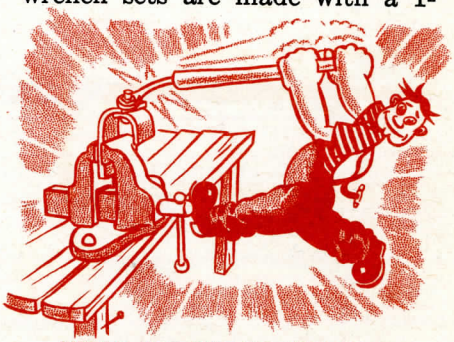
others you set the dial for the amount of torque or twisting effort you wish to apply. Then, when you pull on the wrench, a light flashes the instant that amount of force is applied.

Nuts such as those used on the cylinder head, or main or connecting rod bearing caps, should be tightened to within certain limits. The amount of torque or twisting force to be applied is usually specified in the manufacturer's service manual. A torque wrench enables you to tell how much torque or twisting force is being applied.

The accuracy of torque-measuring depends a lot on how accurately the threads are cut, the amount of lubrication applied to the threads and the type of lubrication. Readings shown by the wrench are much more accurate when the threads are lubricated. Therefore, threads in cylinder head nuts and bearing bolt or stud nuts always should be lubricated before they are replaced and tightened.

All of the well-known makes of socket wrench sets are made of high quality materials, and if not misused they can be depended upon to give long service. The important thing to remember is that the sockets and the handles never should be over-stressed. Never use a bar on a socket wrench handle to increase the leverage. Keep the set clean. Socket wrenches and all the other tools you use will get dirty, especially when working on transmissions, differentials and crankcases. When they do, wipe off the grease and the dirt—give the sockets an occasional bath. Grit, no matter how fine it may be, is an enemy of the working parts of socket wrenches or any other mechanism. Keeping your tools clean and your hands wiped off helps keep grit out.

Socket wrench sets are made in four sizes which are designated by the size of the square on the drive end of the handle. Sets with one-quarter inch drive ends are for light work. For average general work $\frac{3}{8}$, $\frac{7}{16}$ or $\frac{1}{2}$ inch drives are used, the $\frac{7}{16}$ inch being usually preferred for all-around work. Heavy-duty series sockets are made for $\frac{3}{4}$ inch drive and for extra heavy duty work socket wrench sets are made with a 1-



NEVER USE PIPE TO INCREASE LEVERAGE

inch drive. If possible, always use a size big enough for the job. This will avoid danger of over-straining either the sockets or the handles.

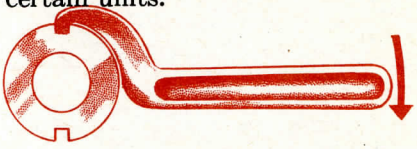
SET-SCREW WRENCHES

ON rare occasions, you may have need for a headless set screw wrench so you should know about the different types. All of them are L-shaped bars of tool steel. The most common type is hexagonal to fit the hexagon socket in the set screw. The trade name for this type is an Allen wrench. The other two types are made from round bar stock and each end is fluted to fit the flutes or little splines in that type set screw. These set screw wrenches vary in size according to the size of the socket in the set screw. Where such special set screw wrenches are required, they are furnished in the special tool kit which accompanies the equipment.

ALLEN WRENCH AND SET SCREW

SPANNER WRENCHES

OUR friends, the British, call most any wrench a "spanner." However, spanner wrenches, as we know them, are special wrenches for special jobs and do not come under the classification of tools for the mechanic's kit. They are supplied as special wrenches in the tool equipment furnished to service certain units.



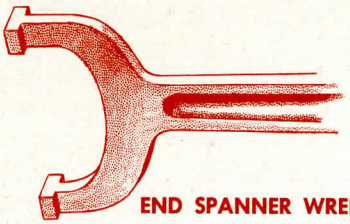
HOOK SPANNER WRENCH

There are a number of types. The "hook spanner" is for a round nut which has a series of notches cut in the outer edge. The hook or lug is placed in one of the notches with the handle pointing toward the direction in which the nut is to be turned. Some hook spanner wrenches are adjustable and will fit nuts of various diameters.

ADJUSTABLE HOOK SPANNER WRENCH

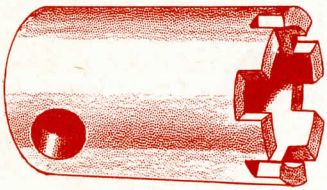
U-shaped hook spanners have two lugs on the face of the wrench to fit notches cut in the face of the nut or screw plug.

End spanners resemble a socket wrench but have a series of lugs on



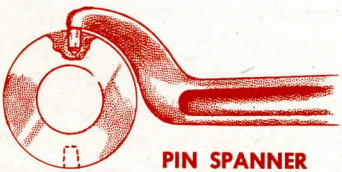
END SPANNER WRENCH

the end that fit into corresponding notches in the nut or plug.



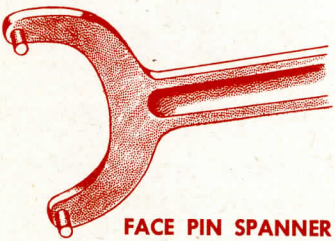
END SPANNER WRENCH

Pin spanners have a pin in place of a lug and the pin fits into a round hole in the edge of the nut.



PIN SPANNER

Face pin spanners are similar to the U-shaped hook spanners except that they have pins instead of lugs.

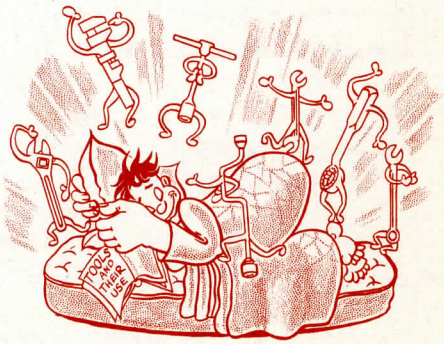


FACE PIN SPANNER

★ ★ ★ ★

WHICH WRENCH TO USE?

NOW that we have talked about all of the wrenches ordinarily used by mechanics, some of you men who are not very familiar with the use of wrenches will perhaps wonder how you are to find out which is the best type of wrench to use for the particular work you are doing. Shall it be an open wrench, an adjustable wrench, a socket wrench, a box wrench or a combination box and open end wrench? This is something that is best learned by actual experience, but there are a few simple rules which will be helpful. The type of job to be done, the location and number of nuts or cap-screws are the things to consider when selecting the wrench. Usually, if there are a number of nuts to be taken off or put on, the socket wrench set is what you should use. In removing the cylinder head from an engine, for example, you would first break the nuts loose by using a socket on a hinged offset handle with the handle bent over at an angle of practically 90 degrees to



provide the necessary leverage. Then after the nuts were broken loose, the hinged handle would be held in the vertical position and twisted with the fingers to run them off. If the engine is installed in a vehicle and there is plenty of room to operate a speed handle, then after breaking the nuts loose with the offset handle, transfer the socket to a speed handle and use this combination to spin the nuts off. In replacing and tightening the nuts, the wrenches would be used in the reverse order.

For such jobs as removing and installing engine oil pans, timing gear cases, and differential case covers, the right size of socket on speeder handle would be the the best wrench to use. It can be used to loosen or tighten these cap-screws because no great amount of force is required.

There are many nuts on various types of vehicles, particularly those on some intake and exhaust manifolds, where box socket or combination box socket and open-end wrenches can be used to good advantage.

For the nuts on fuel and oil lines, hydraulic brake lines, clutch and transmission control rods, brake rods and cable ends, open-end wrenches usually are the only wrenches that can be used.

You men are going to get actual experience in the shop, and after using each type of wrench in the tool kit a few times you will find that, with a little thinking, it is not at all difficult to select the type best suited for the job and to pick the right size wrench.

"A good mechanic is the man who can use his head as well as his hands. The man who can coordinate his brain and muscles—who can do his work well and do it fast, will always get to the top".

For instance, in replacing cylinder head nuts you will find you can get the job done in about half the time if you use both hands simultaneously instead of just one. It is something like learning to use a typewriter—the beginner starts with two fingers but the experienced typist uses all ten. It is just a matter of practice.

★ ★ ★ ★

CHISELS

COLD chisels are used for cutting metal. The one most generally used is the flat cold chisel. The mechanic has need for this tool to cut rivets, cut thin metal sheets, chip metal and to split nuts.

COLD CHISEL

Chisels are made from tough, high carbon steel. Usually the bar stock from which the chisel is forged is octagonal (eight-sided) but may be hexagonal (six-sided), round, square or rectangular. The width of the cutting edge of a cold chisel denotes its size.

In addition to flat cold chisels, there are several other types which sometimes are very useful in general repair work.

The cape chisel which is quite narrow in width is used to cut keyways, narrow grooves and square corners.

CAPE CHISEL

The round nose chisel is used for cutting semi-circular grooves and chipping inside corners which have a fillet or radius.

ROUND NOSE CHISEL

The diamond point chisel is made square at the point, then ground on an angle across diagonal corners which makes the cutting face diamond-shaped. It is used for cutting "V" grooves and square corners.

DIAMOND POINT CHISEL

After the cutting edge of a cold chisel is correctly formed by grinding, it is hardened and then tempered. Hardening the chisel gives it the property of being able to cut metal. But after it is hardened, it must be tempered. Otherwise, the cutting edge would be so brittle that it would probably break the first time it was used.

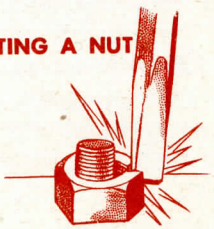
There are a number of important things to remember about chisels—

Always use a chisel that is big enough for the job.

Use a hammer that is heavy enough for the size of the chisel—the larger the chisel, the heavier the hammer.

Ordinarily a chisel should be held in the left hand with the

SPLITTING A NUT



thumb and first finger about an inch from upper end of the chisel. Hold the chisel with a steady but rather loose grip with finger muscles relaxed. That way, if you miss the chisel with the hammer and strike your hand it will slide down the chisel and lessen the effect of the hammer blow on your hand. The best thing to do, of course, is to not miss hitting the chisel.

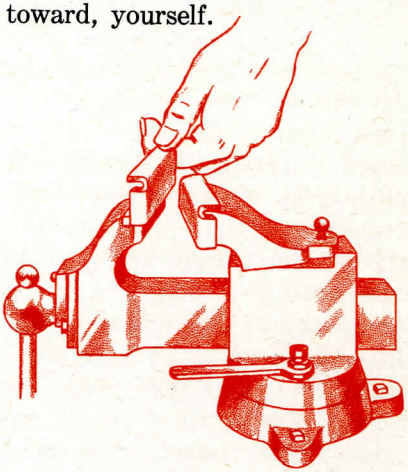
When chipping metal, the depth of the cut is controlled by the angle at which you hold the chisel. Don't try to take too deep a cut. For rough cuts, one-sixteenth of an inch is enough, with half that much or less for finishing cuts.

Keep your eyes on the cutting edge of the chisel. Swing the hammer in the same plane as the body of the chisel. Strike one or two light blows to check your "swing," then increase the force as required.

When using a chisel for chipping, always wear goggles to protect your eyes. If there are other men close by, see that they wear goggles or are protected from flying chips, or else put up a screen or shield to keep the chips from hitting anyone. These two precautions can save many a man from losing the sight of an eye. Remember that the time to take these precautions is before you start the job. After a person is injured, it's too late.

TO CUT OFF A LARGE RIVET HEAD, FIRST CUT GROOVE THROUGH CENTER OF RIVET HEAD WITH CAPE CHISEL AS SHOWN IN A. THEN CUT OFF HEAD WITH FLAT CHISEL AS SHOWN IN B.

If you are using a chisel on a small piece, clamp it rigidly in a vise. Chip toward the solid or stationary jaw of the vise. Chip in a direction away from, never toward, yourself.



To avoid marring or otherwise damaging finished surfaces on a piece which has to be clamped in a vise with roughened jaws, use copper jaw covers. These are frequently called "soft jaws" or "caps."

The cutting edge of a chisel must be sharp in order to cut. It is sharpened by dressing it on an emery wheel. When sharpening a chisel, try to maintain the original angle of the cutting edge by grinding only a small amount at a time from each side. Hold the chisel against the wheel with very little

BEFORE AND AFTER DRESSING

pressure to avoid overheating and dip the cutting end of the chisel in water often enough to keep it cool. Otherwise you will draw the temper and the cutting edge will be soft and the chisel useless until it is rehardened and tempered. This is a job that can be done only by an experienced heat-treater. The cutting edge should be ground on a slight radius—higher in the center than at the ends.

After dressing the cutting edge of a chisel on an emery wheel, inspect the other end. Sometimes it becomes upset or "mushroomed"—spread out like an umbrella—as a result of hammering. It's dangerous to hammer on a chisel or punch which has been upset. Pieces may fly off and cause injury. Grind off the upset metal so the end of the chisel will be slightly tapering and comparatively flat across the top.

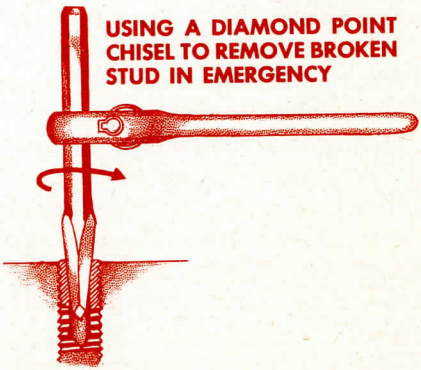
Flat cold chisels are the ones most frequently used by mechanics but the other types mentioned have helped many a mechanic out of a "tight spot" when the right tools to do the job were not at hand.

For example, there are several types of extractors for removing broken studs —the portion of the stud remaining in the part after the stud has been twisted in two. If you have to remove a broken stud and have a set of these extractors, the job will be comparatively simple. If you don't have the extractor, the broken stud can be removed with the aid of a chisel.

Here are two methods—"tricks of the trade," and I am going to pass them on to you.

In either case, you put a center punch mark exactly in the center of the stud, then drill a small hole down into the stud. Follow with one or two larger size drills so that practically all that remains of the stud is a thin sleeve with the threads on it. Do not use a drill so large that it will cut into the threads. Next use a diamond point chisel and lightly tap it into the hole. Put an adjustable wrench on the square of the chisel and back out the broken stud.

If a diamond point chisel of the correct size is not available, you can use a round nose chisel and start breaking the stud threads out of the tapped hole and thus collapse the remaining portion of the stud so that it can be removed.



USING A DIAMOND POINT CHISEL TO REMOVE BROKEN STUD IN EMERGENCY

The diamond point chisel isn't intended for use as a stud extractor, but like many other instances that might be considered as misuse of a tool, it's a way to get the job done if the right tool is not available. In all such cases, the tool being used as a substitute must be used carefully so as not to damage or destroy it.

In ordinary automotive service work on cars or trucks, it's usually easy to obtain replacement parts. But when you have to do a repair job and can't get the replacement parts you have to use your ingenuity. The first-class army mechanic uses a lot of ingenuity to keep his jobs rolling at the fighting front.

Probably some very interesting maintenance stories could be told by those mechanics who serviced the planes for the "Flying Tigers" in China. With a minimum of spare parts and very few facilities, they managed make-shift repairs chiefly through sheer ingenuity and kept the "Flying Tigers" flying. That's what counts when you're fighting a war!

PUNCHES

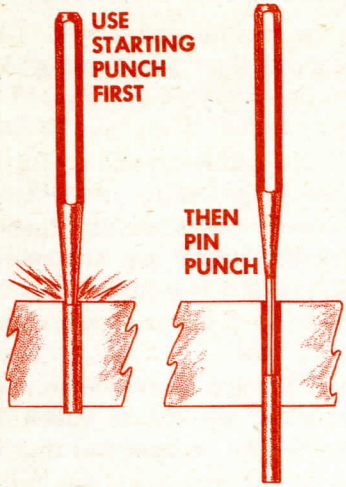
"STARTING PUNCHES", sometimes called drifts, are made with a long, gentle taper which extends from the tip to the body of the punch. They are made that way to stand heavy shock blows. This type punch is used to knock out rivets after the heads have been

STARTING PUNCH

cut off. It also is used to start driving out straight or tapered pins because it can withstand the heavy hammer blows required to break loose the pin and start it moving.

PIN PUNCH

After the pin has been driven partially out of the hole, the starting punch can no longer be used. The increasing taper on the punch becomes too large for the hole. Then the punch to use is a "pin punch." The pin punch is made with a straight shank—no taper—so that it fits into the hole. Always use the largest size of starting and pin punches that will fit the hole. Never use a pin punch to start a pin because, since it has a slim shank, a hard blow on the punch may cause it to bend or



break. Starting punches and pin punches usually come in sets of various sizes with 3 to 5 punches in a set.

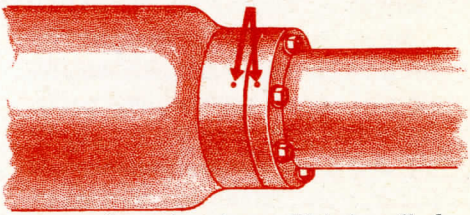
Every tool kit should contain an "aligning" or "lining-up" punch which is from 12 to 16 inches long, made from $\frac{5}{8}$ or $\frac{3}{4}$ inch bar stock. This punch has a long taper and is useful in shifting parts so corresponding holes "line-up". The punch is especially handy when making engine installations, replacing chassis springs, fenders and running boards, and many other jobs.

CENTER PUNCH

Another punch which is very valuable to the mechanic is the center punch. The center punch

always is used to mark the location of a hole that is to be drilled. When the drill is placed in the center punch mark, it starts drilling the hole at that particular point. If you try to drill a hole without first locating it with a center punch mark, the drill usually will start to move all

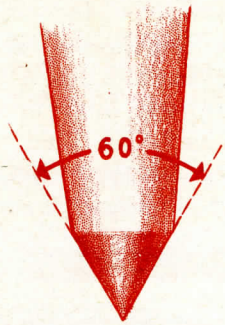
PUNCH MARKS MAKE IT EASY TO ASSEMBLE TWO PARTS IN ORIGINAL POSITION



around on the piece. This is called "wandering" and when a drill starts to wander, the mechanic hasn't any control of the exact location of the hole.

Frequently, the cautious mechanic will use a center punch to make some corresponding punch

ALIGNING PUNCH



CENTER PUNCH POINT

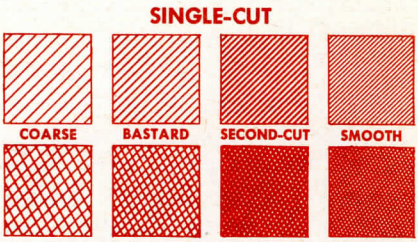
marks on two or more parts in an assembly before he starts taking it apart. This will enable him to reassemble the parts in their original positions.

The point on a center punch is accurately ground to a true taper point which is central with the shank. The included angle is usually 60°. It requires considerable experience to grind a center punch point by hand with any degree of accuracy. For this reason, you should take good care of your center punch. Don't use a center punch on metal which is so hard that it may dull the point.

FILES

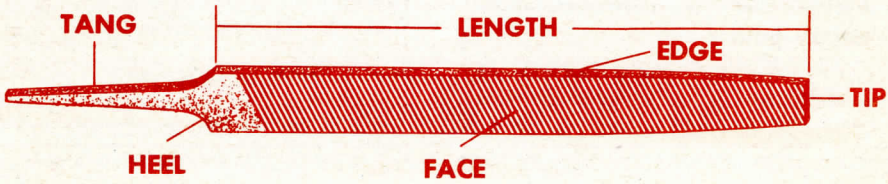
A mechanic's tool kit would not be complete without an assortment of files. In automotive repair work, there are occasions when a file is a very necessary tool. There are more than 20 types of files. Sizes for each type may range from 3 to 18 inches. They may be either single or double cut and are further classified according to different grades of coarseness or fineness, depending on the size and spacing of the teeth. It would take a long time to learn about all the various type of files.

The portion of the file on which the teeth are cut is called the "face". The tapered end that fits into the handle is called the "tang".



The part of the file where the tang begins is the "heel". The length of a file is the distance from the point or tip to the heel and does not include the tang. In other words, it is the total length of the file minus the length of the tang.

The teeth of the file do the cutting. These teeth are set at an angle across the face of the file. A file with a single row of parallel teeth is called a single-cut file.



FILES

SINGLE-CUT FILE

DOUBLE-CUT FILE

The teeth are cut at an angle of 65 to 85 degrees to the center-line, depending on the intended use of the file.

Files which have one row of teeth crossing another row in a criss-cross pattern are called double-cut files. The angle of the first set usually is 40 to 50 degrees and that of the crossing teeth 70 to 80 degrees. Criss-crossing produces a surface which has a very large number of little teeth all slanting toward the tip of the file, each little tooth like the end of a diamond-pointed cold chisel.

Files are graded according to the tooth spacing—a coarse file has a small number of large teeth and a smooth file has a large number of fine teeth. The coarser the teeth, the more metal will be removed on each stroke of the file. The terms used to indicate the coarseness or fineness of a file are: Rough, coarse, bastard, second-cut, smooth and dead-smooth. And the file may be either single-cut or double cut.

Files further are classified according to their shapes and, as previously mentioned, there are more than 20 different shapes. To keep the subject of files from becoming too complicated and talking about many files you will never see or use, we shall limit the discussion to 8 files which will be satisfactory for most filing jobs required in maintenance work.

The 12-inch flat bastard file for general rough filing.

The 12-inch second-cut mill file for removing a small amount of metal and making the filed surface smooth. All mill files are single-cut.

The 12-inch half-round bastard file. The rounded face of this file is used to file a surface having large concave radius. The flat face can be used for general rough filing.

The 12-inch round bastard file is used for enlarging holes, also for filing surfaces having small concave radii.

The 6-inch smooth mill file is used for all small work where surfaces are flat or convex.

The 6-inch half-round second-cut file is used for purposes similar to

the 12-inch half-round but on smaller work where there is not so much metal to be removed.

The 6-inch three-square or triangular file. Very useful for filing small notches, square or cornered holes, and for straightening up burred or damaged threads.

The 6-inch round file, frequently called a rat tail file, is used for purposes similar to the 12-inch round file but on smaller work.

We have been talking about concave and convex surfaces and some of you may not understand which is which. A curved surface that

CONVEX SURFACE CONCAVE SURFACE

is hollow—one which "caves in" is "concave". A curved surface which arches outward is convex. The front face of a headlamp lens is convex, the rear face is concave.

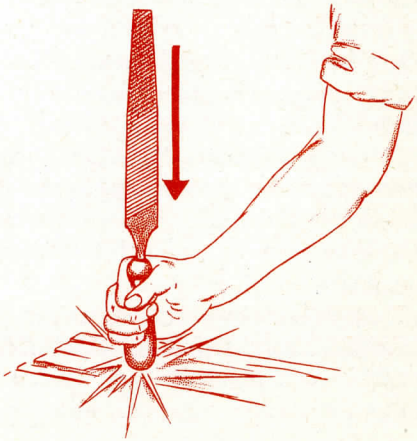
THE USE AND CARE OF FILES

BEFORE attempting to use any file, it should be equipped with a tight fitting handle. It is dangerous to use a file without a handle. Often the end of the tang is quite sharp and if you are using a file

IT IS DANGEROUS TO USE A FILE WITHOUT HANDLE

without a handle and the file meets an obstruction and is suddenly stopped, the pressure of your hand against the end of the tang may result in a bad cut. Remember, the real mechanic—the man who is careful in the way he goes about his work and uses tools—never has need for a first aid kit.

To put a handle on a file, first make sure the handle is the right size and that the hole is large enough for the tang. Insert the tang of the file into the hole in the handle, then tap the back end of the handle on the bench or a flat



surface on the vise. Make sure the handle is on straight.

To remove a file handle, hold the handle in your right hand and hold the file with your left hand and give the ferrule end of the handle a sharp rap against the edge of the bench or the side of a vise jaw. The ferrule is the metal sleeve on the hole end of the handle to keep the handle from splitting when the tang of the file is forced into the hole.

Whenever possible, the part to be filed should be clamped rigidly in a vise. To prevent rough vise jaws from damaging finished surfaces, use copper caps or other soft material.

In using a file, remember that the teeth are made to cut in one direction only—when the file is being pushed forward. All pressure of the file against the work should be relieved on the back stroke. Holding a file against the work on the back stroke serves only to help dull the cutting edges of the teeth. The preferred method of using a file is to raise it off the work before drawing it back. Files stay sharper longer when used that way.

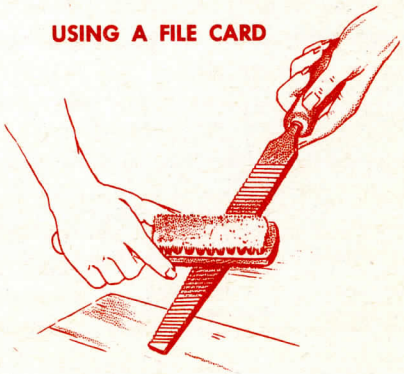
I call a mechanic who drags a file on the back stroke a "shuffler". It reminds me of a man who is too lazy to pick up his feet when he walks.

However, there are exceptions to this rule, as there are to many others for the use of tools. When draw-filing, for example, the file rests on the work at all times. The file is pushed across the work crosswise and very little metal is removed. Draw-filing is a finishing-up operation when filing an accurate flat surface.

Beginners frequently have difficulty in knowing how much pressure to use on a file. They usually are told to "bear-down" on the file without being told that using too much pressure is almost as bad as using too little pressure. The point to remember is to USE ONLY SUFFICIENT PRESSURE TO KEEP THE FILE CUTTING. Different metals and different files call for a difference in the amount of pressure you should apply to the file.

Never use a file after the teeth become "choked" or clogged with particles of metal. The experienced filer will bump the tip of the file or the end of the handle on the bench every now and then while filing to jar loose the filings which stick in the teeth. This won't always get all the chips out though, so the thing to do when the file gets "loaded" is to clean the teeth

USING A FILE CARD



FILES ARE NOT PRY BARS

with a file card. This is a brush with short, stiff wire bristles. If there are any chips remaining after using the file card, these should be dug out with a pointed or flattened cleaning wire called a "scorer". Usually a file card has a scorer attached to the handle.

A file which is loaded with chips is apt to roughen a surface which you are trying to file smooth, especially if the material you are filing is steel.

Files must be sharp to do their best work. Metals which are soft and tough, such as copper and some of the brass alloys, require the use of very sharp files.

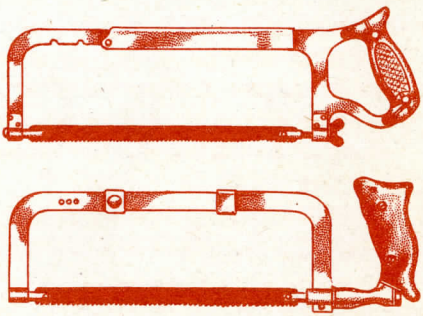
To keep files sharp, see that their surfaces are protected when not in use. The best way to protect files in the shop is to hang them in a rack which has a series of slots. Files which are carried in a tool box should be wrapped in cloth, paper or other material which will protect them from other tools. Don't throw files around on a bench or into a drawer with other tools and expect them to stay sharp. Keep files away from moisture and water to prevent rusting.

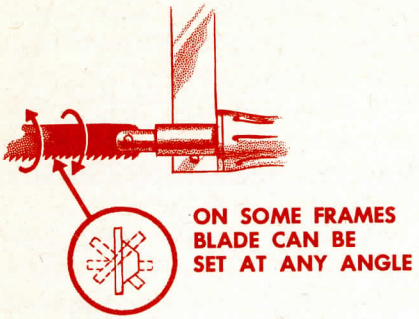
Never use a file for prying. The tang end is soft and bends easily. The body of the file is hard and very brittle. A light bending force will snap it in two.

A final and very important precaution is—never hammer on a file. This is positively dangerous because it may shatter with chips flying in every direction.

HACKSAWS

THE hacksaw is used to saw metal. There are two parts to a hacksaw—the frame and the blade. Practically all hacksaws now are made with an adjustable frame designed to take blades which are 8, 10 or 12 inches long. The better frames are made with a pistol grip handle. Recently, several manu-

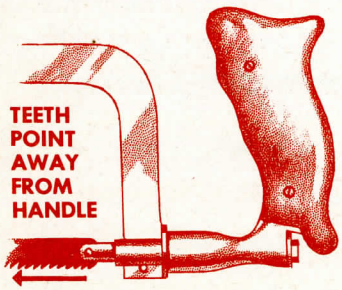




facturers have developed frames with the handle in an inverted position. The theory of this design is that the force applied on the forward stroke of the saw is delivered in a direct line with the blade.

All adjustable hacksaw frames are made so the blade can be installed in a vertical or horizontal position. In some of the more expensive, better designed frames, the saw blade can be positioned at various angles between the vertical and horizontal positions. Often there is an advantage in having a hacksaw of this type because it enables the mechanic to use the saw in places where there would not be sufficient clearance for the conventional saw with only two positions for the blade.

When placing a blade in a hacksaw frame, first see that the frame is correctly adjusted for the length of the blade with sufficient adjustment remaining to permit the blade to be tightly stretched.



Place the blade on the pins so that the teeth point toward the front of the frame—away from the handle. Occasionally a beginner gets a saw blade in backwards and then wonders why the saw doesn't cut. Always screw up the adjustment so that the blade is rigid in the frame.

In starting a cut which is being made to a marked line it usually is a good idea, especially for the apprentice, to use the thumb of the left hand to guide the blade until the cut is started at the desired location. Use sufficient pressure in starting the cut so that the saw immediately begins to bite into the metal. The cutting action of a hacksaw blade and a file are similar—if you don't use sufficient pressure so that the teeth actually bite into and cut the metal, the rubbing action helps dull the teeth. When sawing, relieve the pressure on the return stroke of the blade in the same manner as is done when filing. It is not necessary to lift the blade off the work when the saw is being started. But when the kerf—that's the term for the slot made by the saw—becomes deep enough to guide the blade, the saw blade can be raised slightly off the bottom of the kerf on each back stroke.

For efficient cutting in metals of

KEEP BLADE FROM JAMMING

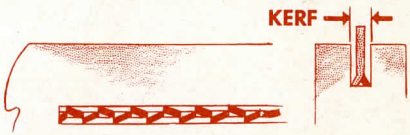
average hardness the saw should be worked at the rate of 40 to 50 strokes per minute. If the saw is worked too fast, there may be sufficient heat generated by the cutting action of the teeth to draw the temper and ruin the blade. In cutting harder metals, the number of strokes per minute should be reduced. There's a limit to the hardness of metal that can be sawed. Before ruining all the teeth on a blade, test the metal with the very front or rear teeth or with the tip of a file to see if it can be cut.

Always use practically the entire length of the hacksaw blade on every stroke except when you are getting the saw started. Keep the blade moving in a straight line to avoid any twisting or binding action. And again, use enough pressure to keep the blade from getting pinched or jammed as this often breaks some of the teeth or breaks the blade.

If a blade breaks and you have to finish the operation with a new blade, always start a new cut with the new blade if possible. If you are sawing a round piece, rotate it and start a new cut in line with the first one. If you are sawing a flat piece, start the cut from the other edge. The reason for this is that a new blade has more "set" than a worn blade and usually will jam the saw. The "set" in a saw refers to how much the teeth are pushed out in opposite directions from the sides of the blade. Set is necessary so that the saw kerf or slot will be slightly wider than the thickness of the blade and thus provide clearance to prevent the blade from sticking in the kerf. Unless extreme care is used starting a new blade in a cut which was made by a used blade, it will jam and that usually causes the blade to break.

Blades for hand hacksaws are made with 14, 18, 24 and 32 teeth per inch. The 18 and 32-tooth blades are suitable for all automotive maintenance work. The 18-tooth blade is used for all sawing except thin metal such as sheets or tubing which is sawed with a 32-tooth blade.

Two or more saw teeth should be in contact with the work at all times. On very thin sheet stock, this is not possible even with the



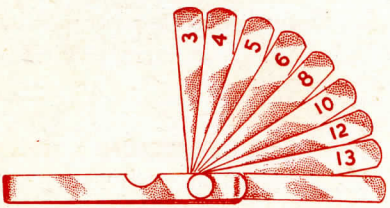
SET OF TEETH PROVIDES CLEARANCE FOR BLADE

32-tooth blade. If you have occasion to saw thin sheet metal, clamp it in a vise between two pieces of wood.

Regarding the care of a hacksaw, see that the blade is properly protected when not in use. In the shop, a hacksaw should be hung up. If a hacksaw is carried in a tool kit, it should be placed in the box so that tools and other metal objects do not rub against the blade teeth. Wiping a blade occasionally with an oily cloth will keep it from rusting.

FEELER GAGES

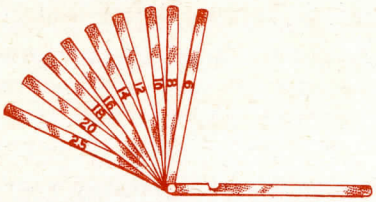
THE performance of gasoline engines used by Army Ordnance largely depends upon the accuracy of various adjustments on the engine such as valve lifter clearances, the spacing of the ignition points and the spark plug gaps. These adjustments require extreme precision—the mechanic must work to the thousandths of an inch. To give you an idea of how much one thousandth of an inch is, it is about one-third the thickness of the average human hair. Most of you men may think, especially if



STEPPED FEELER GAGE

you examine one of the hairs in your head, that working to the thousandths of an inch would be doing extremely accurate work, but men in the machine tool industry work to one ten-thousandth and even one one-hundred-thousandth of an inch.

The feeler gage is the tool which enables the automotive mechanic to work to thousandths of an inch. There are several types of feeler or thickness gages but all have a number of blades of various thicknesses hinged in a holder. Some "feelers" have short blades, as many as 23, starting with a blade one and one-half thousandths of an inch in thickness and including blades up to 35 or 40 thousandths of an inch thick. "Stepped feelers" have each blade made in two thicknesses. About the first half inch of the tip of the blade is two thousandths of an inch thinner than the remainder of the blade. If, for example, the tip of a blade measures 4 thousandths of an inch thick, then the other portion would measure 2 thousandths thicker or 6 thousandths of an inch. This type feeler gage is convenient in adjusting valve clearances. Suppose the clearance for intake valves was specified at 6 to 8 thousandths. You would use the 6 to 8 thou-



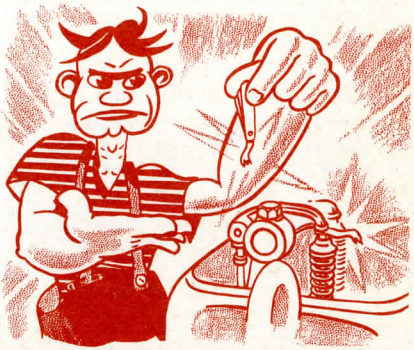
FEELER GAGE FOR BRAKE WORK

sandths blade and make the adjustment so that the 6 thousandths end of the blade would go through the clearance gap and the 8 thousandths portion would not. Thus, you would know the clearance was between 6 and 8 thousandths. A stepped feeler is called a "go" and "no go" gage.

Feeler gages for adjusting the clearances between brake shoes and brake drums are made with long, narrow blades which can be inserted through the inspection slots in the brake backing plates or brake drums.

Some feeler gages made for adjusting spark plug gaps have L-shaped wires of various diameters mounted on the blades. A spark plug which has been in service for any length of time usually has a slight hollow burned into one of the electrodes by the sparks. Such a plug can be set much more accurately by using a round wire feeler instead of the conventional type.

Concerning the care and use of feeler gages—remember that they are precision measuring tools, and therefore deserve the best of care. In the better quality feeler gages, the blades are high quality tempered steel accurately ground to the thickness marked on the blade. Unless the blade is used carefully, it may become bent, torn or broken. When you use a feeler gage to check valve clearances or the clearance between other parts such as the thrust surfaces on crankshafts and main bearings, never get the blade wedged in the clearance space. When adjusting valves, if you can't slide the feeler used to measure the minimum clearance through the space without exerting force, there is not enough clearance and the adjustment should be changed. A feeler gage should always be moved in the same plane as the blade so there is never any twisting or bending of the blade. The good mechanic, the man who values his tools, will occasionally wipe the blades of his feeler gage with a clean oily cloth to remove any dirt and prevent the blades from rusting.



NEVER EXERT FORCE ON A FEELER GAGE

OTHER MEASURING TOOLS

IN addition to the feeler gage, there are some other measuring tools used by mechanics with which you should be familiar.

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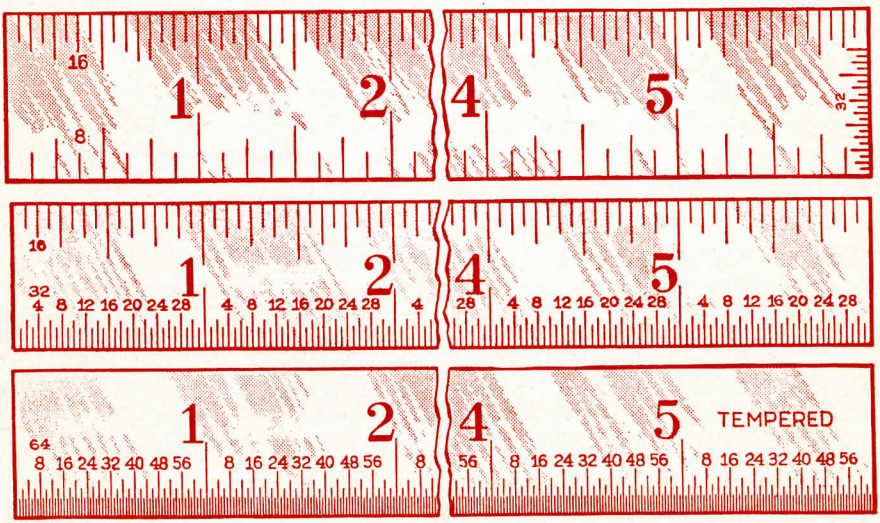
THE 6-INCH STEEL RULE

FOR small measurements which do not have to be accurate to more than 10 thousandths of an inch, the 6-inch steel rule is used. Usually it is called a 6-inch scale and many men in the shop refer to it simply as a scale. There are flexible and non-flexible types. The thinner the rule the easier it is to measure with accuracy because the division lines are closer to the work. For this reason, the thin flexible rule or scale is preferred.

Ordinarily there are four sets of graduations on steel rules, one on each edge of each face or side. Graduations are the lines which mark off the divisions. The longest lines represent the inch marks. On one edge each inch is divided into 8 equal spaces and each space therefore represents one-eighth of an inch. The other edge on this face of the rule has each inch divided into 16 spaces and thus each division represents one-sixteenth of an inch.

On the other side of the rule, one edge has the inches divided into 32 spaces. One edge measures in thirty-seconds and the other in sixty-fourths of an inch. One sixty-fourth of an inch is slightly less than 16 thousandths.

For measuring dimensions greater than 6 inches and up to 12 inches, the 12-inch steel rule is used. This rule usually is gradu-



ated the same as the 6-inch rule just described.

There are times when the mechanic has to measure dimensions much longer than 12 inches. One example of this would be when straightening a truck frame. For such measuring the flexible steel tape rule is very convenient.

The blade of this rule rolls up in the case when not in use, making the rule very convenient to stow in the tool kit. Ordinarily these rules are long enough to measure 72 inches or 6 feet. The inches are divided into sixteenths, with the first inch and often the first six inches graduated in thirty-seconds of an inch.

ENGLISH AND METRIC UNITS

INCHES, feet and yards, the common units of linear measure used in the United States, are units of an English system of measurement.

The metric system, used in many foreign countries such as France, Germany, Italy and Spain, is based entirely on multiples of ten. The units are divisions of, or multiples of, the meter.

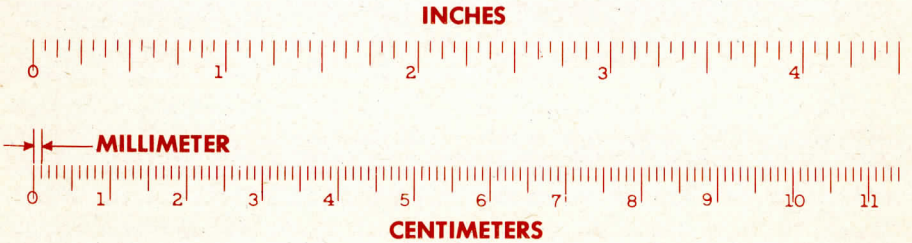
10 millimeters (mm.)	=	1 centimeter (cm.)
10 centimeters	=	1 decimeter (dm.)
10 decimeters	=	1 meter (m.)
1000 meters	=	1 kilometer (km.)

METRIC AND ENGLISH CONVERSION TABLE

LINEAR MEASURE

1 kilometer	=	0.6214 mile
1 meter	=	39.37 inches
	=	3.2808 feet
	=	1.0936 yards
1 centimeter	=	0.3937 inch
1 millimeter	=	0.03937 inch
1 mile	=	1.609 kilometer
1 yard	=	0.9144 meter
1 foot	=	0.3048 meter
1 foot	=	304.8 millimeters
1 inch	=	2.54 centimeters
1 inch	=	25.4 millimeters

The only standard of measurement that has been legalized by the United States Government (in 1866) is the meter. The United States yard is defined by its relation to the meter. One yard equals $\frac{3600}{3937}$ of a meter.

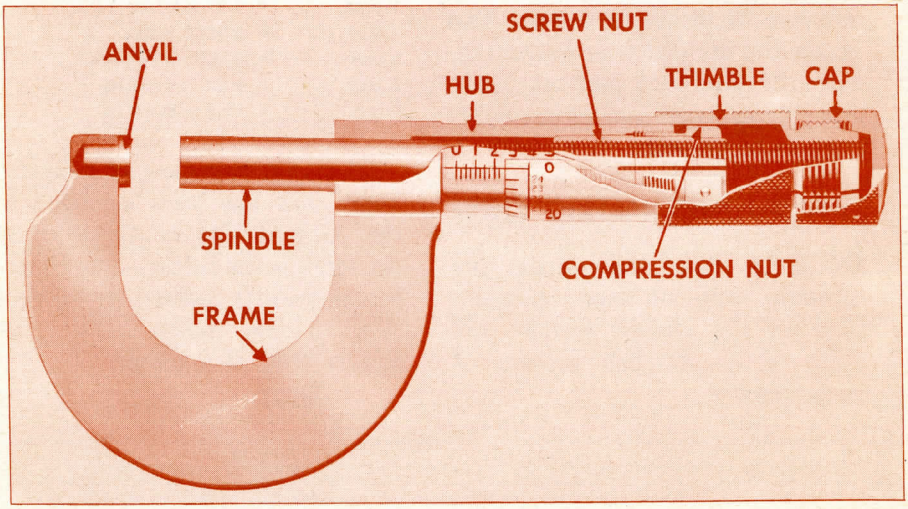


Much of our armament and ammunition sizes are in millimeters. A millimeter (abbreviated as mm.) is one-thousandth of a meter or 0.03937 inch.

MICROMETERS

THE micrometer caliper, more often called a micrometer or a "mike", measures in the thousandths parts of an inch.

Toolmakers and machinists use micrometers almost continually. The mechanic uses them chiefly for measuring wear on engine parts such as piston pins and valve stems to determine whether the worn parts should be replaced with new ones.



The cut-away illustration with the parts named shows how a micrometer is constructed. It makes use of the principle of the screw thread. The portion of the spindle which extends through the hub is threaded and works in the screw nut which is pressed into the hub. The part called the thimble is rigidly attached to the spindle. Turning the thimble clockwise screws the spindle toward the anvil. Turning it counter-clockwise screws the spindle away from the anvil. The piece to be measured is placed between the anvil and the spindle, or the micrometer is held over and around the piece, and the spindle screwed down until it touches the piece with only the lightest of pressure. The spindle is screwed down only enough to take up the clearance and get an accurate reading. You should be able to slide the micrometer across the piece being measured to indicate that there is no amount of clamping action. CLAMPING A MICROMETER TIGHTLY ON THE PIECE WILL QUICKLY RUIN THE MICROMETER.

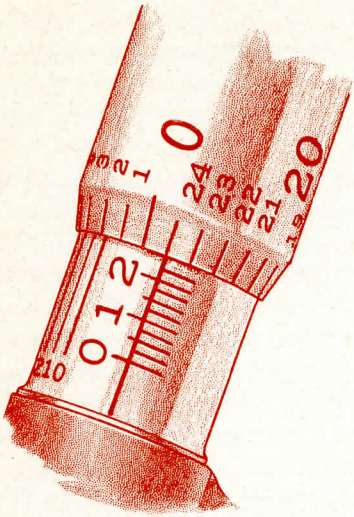
There are 25 equal spaces around the tapered edge of the thimble. Each space represents one thousandth of an inch. Turning the thimble one space changes the opening between the end of the spindle and the anvil by one thousandth of an inch. The reason for this is simple. The screw thread on the spindle is cut with forty threads to the inch. Starting with the spindle down against the anvil, 40 complete turns of the thimble would move the spindle away from the anvil exactly one inch. Thus one complete turn of the thimble would move the spindle one-fortieth of an inch. And one-fortieth of an inch is 25 thousandths of an inch, which is why there are 25 divisions around the spindle, each representing one thousandth of an inch.

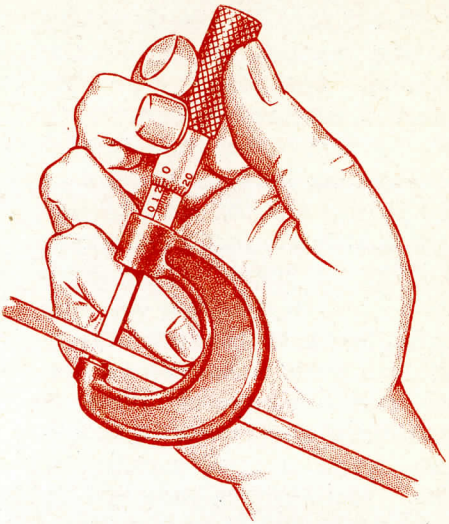
There also are graduations on the part called the hub. Through these cross lines is a line running lengthwise of the hub called a reference or datum line. The smallest divisions on the hub graduations represent 25 thousandths of an inch which is one complete turn of the thimble. Every fourth cross line is numbered and represents 4 complete turns of the thimble or 4 times 25 thousandths which is 100 thousandths. The figures on the hub therefore represent one hundred thousandths of an inch. Figure 1 is one hundred thousandths, figure 2 is two hundred thousandths and so on.

To make all this more understandable, we will screw the spindle down against the anvil very lightly. There is no space between the spindle and anvil. The zero line on the thimble now lines up with the zero line on the hub—the micrometer reading is zero. Then we unscrew the thimble one graduation mark. Now the opening between the spindle and the anvil is one thousandth of an inch—an amount so small that it is barely visible to the eye unless the micrometer is held up to the light. We continue to unscrew the thimble until the line at the figure 5 on the thimble is lined up with the reference line on the hub and the opening between the spindle and anvil now is 5 thousandths of an inch. When we have unscrewed the thimble one complete turn, the zero line on the thimble is in line with the reference line on the hub and the thimble has uncovered the second graduation mark or the first space on the hub which represents 25 thousandths of an inch.

Now for some actual measuring with the micrometer—we adjust the micrometer to this piece of round bar stock.

The figure 2 on the hub represents two hundred thousandths. The next graduation line on the hub represents 25 thousandths more —that makes 225 thousandths and to this we add the thimble reading which is 24 thousandths, making a total of 249 thousandths





of an inch. The piece measures 249 thousandths, one thousandth less than 250 thousandths or one-quarter inch.

With an understanding of the principle and a little practice it is as easy to read a micrometer as it is to tell time with a watch.

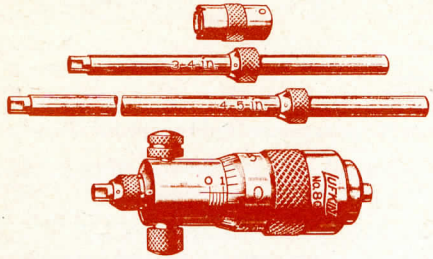
The better grade of micrometers usually carry a table of decimal equivalents on the frame for convenience. It shows fractional parts of an inch and their equivalent decimals.

Micrometers have an adjustable measuring range of only one inch. Measurements of more than one inch and less than two inches are made with a micrometer which measures from 1 to 2 inches—of more than two inches with a micrometer which measures from 2 to 3 inches, and so on.

The inside micrometer is used to measure inside dimensions such

DECIMAL EQUIVALENTS

1/64 .0156	17/64 .2656	33/64 .5156	49/64 .7656
1/32 .0312	9/32 .2812	17/32 .5312	25/32 .7812
3/64 .0468	19/64 .2969	35/64 .5469	51/64 .7969
1/16 .0625	5/16 .3125	9/16 .5625	13/16 .8125
5/64 .0781	21/64 .3281	37/64 .5781	53/64 .8281
3/32 .0937	11/32 .3437	19/32 .5937	27/32 .8437
7/64 .1094	23/64 .3594	39/64 .6094	55/64 .8594
1/8 .125	3/8 .375	5/8 .625	7/8 .875
9/64 .1406	25/64 .3906	41/64 .6406	57/64 .8906
5/32 .1562	13/32 .4062	21/32 .6562	29/32 .9062
11/64 .1719	27/64 .4219	43/64 .6719	59/64 .9219
3/16 .1875	7/16 .4375	11/16 .6875	15/16 .9375
13/64 .2031	29/64 .4531	45/64 .7031	61/64 .9531
7/32 .2187	15/32 .4687	23/32 .7187	31/32 .9687
15/64 .2344	31/64 .4844	47/64 .7344	63/64 .9843
1/4 .25	1/2 .5	3/4 .75	1 1.0



as cylinder bores. It is read in the same manner as the micrometer used for outside measuring.

SCREW EXTRACTORS

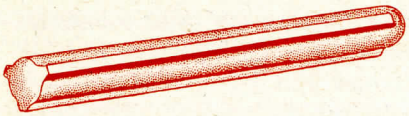
SCREW extractors are used to remove broken screws or studs and often are called stud extractors. When we talked about chisels, methods were described for removing a broken stud with the aid of a diamond point chisel and with a round nose chisel. They were emergency methods to be used if a stud extractor were not available. Using an extractor is a much easier and quicker method.

There are several types of extractors, all supplied in sets with sizes for screws of various diameters. Perhaps the most commonly used type is the Ezy-Out which is tapered and has a coarse spiral, resembling a thread, with very sharp ridges. To use this tool a hole is drilled in the exact center of the broken screw or stud. The size of the hole should be a little less than the small diameter of the screw threads to avoid the danger of drilling into and ruining the threads in the tapped hole. Then an extractor of the right size is inserted into the hole and turned with a wrench in a lefthand or counter-clockwise direction. The sharp ridges on the extractor "bite" into the sides of the hole in the broken stud so that it can be screwed out.

REMOVING BROKEN STUD WITH EXTRACTOR

Another type of tapered extractor is made with four straight flutes which have sharp edges. This tool is tapped into the drilled hole with a hammer to force these sharp edges into the sides of the hole and grip the broken stud so it can be unscrewed.

A third type of extractor is perfectly straight, without any taper, and has three sharp splines. Drills are furnished with this set to drill the right size hole for each extractor, and pilots to center the drills also are included. The extractor is slightly larger than the hole made by the drill. The extractor is driven into the hole with a hammer and gets sufficient grip on the broken stud to permit screwing it out.



ANOTHER TYPE OF EXTRACTOR

It requires mechanical judgment to use extractors, especially the smaller sizes. All of them are hardened and therefore are brittle. Consequently, after the extractor gets a "bite" on the broken screw or stud, the force should be applied gradually to prevent breaking the extractor.

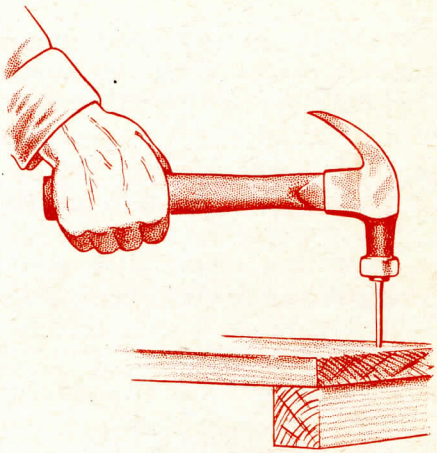
In drilling a hole in a broken stud for an extractor, it is a good idea to drill a small hole first to serve as a pilot hole for the larger drill. It is important that the first hole be drilled exactly in the center of the broken stud. Check this at the start of the drilling operation. The advantage of starting the hole with a small drill is that if inspection shows that the hole is not starting exactly in the center, the drill can be manipulated at the start to slightly shift the location and center the hole.

CARPENTER'S TOOLS

THERE are times when the mechanic in civilian life has need for a few carpenter's tools—either to build a bench, some shelves, or to crate or uncrate parts. You army mechanics also might have occasion to use some of these tools and should know something about a few of them.

THE NAIL HAMMER

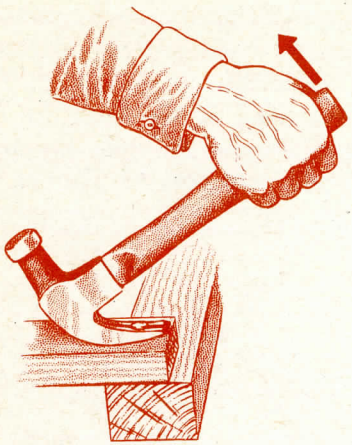
THE nail hammer, often called a claw hammer, is used for driving and drawing or pulling nails. When using it to hammer, grasp the handle firmly and near the end. According to the force of the blow to be struck, force is applied through the wrist, elbow or shoulder. A light force is delivered by wrist action. A combination of wrist and elbow is used for more force, and wrist, elbow and



shoulder action are used for a blow of maximum force.

To drive a nail, hold it between the thumb and forefinger, rest the hammer on the head of the nail, then draw the hammer back and give the nail a light tap to start it. Resting the hammer on the nail before drawing it back increases the accuracy of your aim.

To use the hammer to pull or draw a nail, the head of the nail must be exposed. Slip the claw



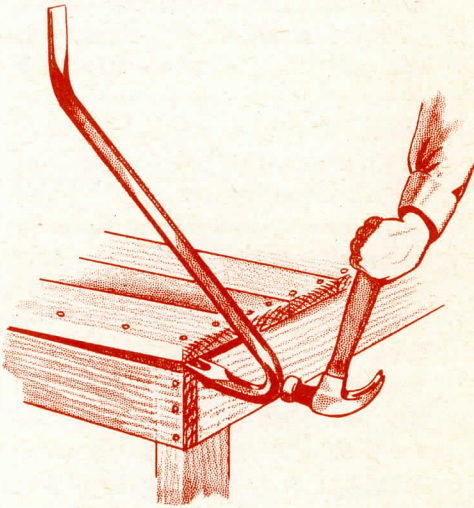
of the hammer under the nail head and pull until the hammer is almost vertical or straight up.

Then to relieve unnecessary strain on the handle and to increase leverage and make it easier to completely draw the nail, use a block of wood under the head of the hammer.

RIPPING BAR

THE wrecking bar, sometimes referred to as a ripping bar, is a

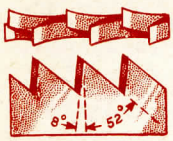
useful tool for uncrating and other prying jobs. The tip of the hook or goose neck end is shaped like the claw of a hammer and can be used to pull nails, the hook serving as the fulcrum of the lever. To enter



the claw under a board on a box and thus get a purchase to pry the board loose, the back of the hook can be struck with a hammer.

HAND SAWS

THERE are two types of hand saws used for sawing wood. One is used to saw in the direction of

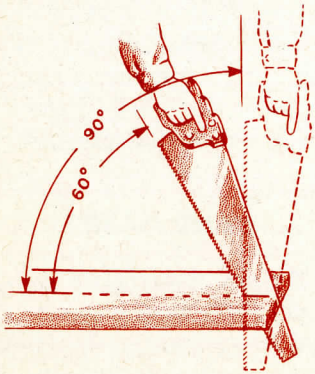


RIP SAW TEETH

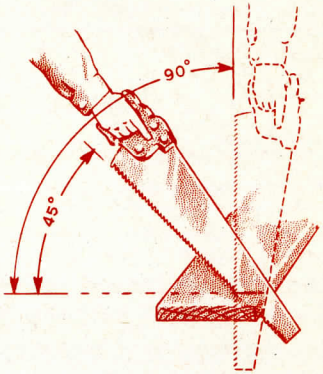
CROSS CUT SAW TEETH

the grain of the wood, the other to saw crosswise of the grain. The grain always runs with the length of the board.

The RIP SAW, used for cutting with the grain or lengthwise of the board, has teeth which are shaped like chisels. The cutting edge of each tooth extends the full width of the tooth and is at right angles to the saw blade. When sawing, the teeth cut into the wood like a row of chisels one in back of the other. The rip saw should be held at an angle of 60 degrees with the board. Holding the saw at this angle provides sufficient force for the saw to cut into the board and no additional pressure in this direction should be applied. Use long, easy strokes. If the saw were held vertical the angle would be 90 degrees. Swinging the handle back and downward through one-third of the arc puts the saw in correct position for ripping.



THE CROSS CUT SAW is used for cutting across the grain or crosswise of the board. The front edges of the teeth are filed with a bevel so that the teeth actually are pointed like the end



of a knife blade. The bevel slopes in one direction on one tooth and in the opposite direction on the next tooth. This provides two parallel lines of sharp points to cut the wood fibers like knives, and the teeth force out the wood between the two cuts. The cross cut saw should be held at an angle of about 45 degrees with the board —half-way between horizontal and vertical. Keeping the index finger along the side of the handle will help guide the blade. Again, use long, easy strokes.

Saws should be kept oiled to prevent rusting. They should be hung up by the handles or otherwise stored so the teeth will be protected against being dulled.

★ ★ ★ ★

This concludes the lecture course on tools. Next you men are going into the shop and get some actual experience. It is not to be expected that you would be able to repeat everything I have told you about tools. However, many of the points I made will come to you when you begin using tools.

I can't put too much stress on the importance of keeping your tools in shape. Always keep your hands and tools wiped clean while you are using them. And also I might mention that all evidence of dirt should be removed before the tools are put away.

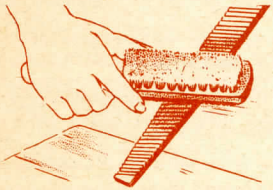
I hope you men who never had any previous experience with tools now have a better understanding of what they are for and how to use them.

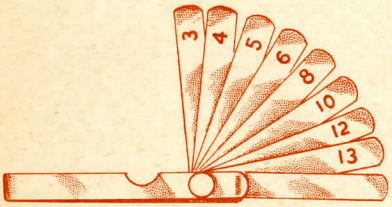
I feel that you have been fortunate to get this information before starting to work. I know I would have appreciated it when I entered the service.

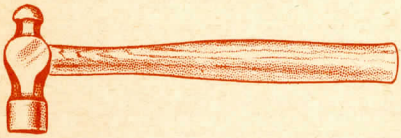
So that as many of our new men as possible can learn about tools, this tool talk will be put in booklet form and will be issued to each man".

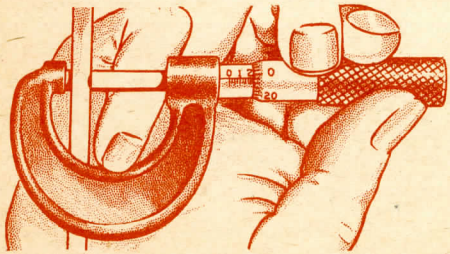
GLOSSARY

PAGES









GLOSSARY